6.1 Introduction

Environmental concerns related to groundwater (GW) generally focus on the impact of pollution and quality degradation in relation to human uses, particularly domestic supply. Due to high population growth and industrialization, greater amounts of domestic and industrial effluents are discharged that lead to the pollution of GW in shallow aquifers. Water pollution is a serious problem in India as almost 70% of its surface water resources and a great number of its GW reserves are already contaminated by biological, organic, and inorganic pollutants (Rao & Mamatha, 2004). The environmental concern related to the GW quality generally focuses on the impact of pollution and quality degradation on human health. Nearly two third of all ailments in India, such as jaundice, cholera, diarrhoea and dysentery, typhoid, etc. are caused by the consumption of polluted water and these water-borne diseases claim nearly 1.5 million lives annually in the country, which means three persons die every 10 minutes due to contaminated water (Ghazali, 1992). Even today more than 90% of our rural population is primarily dependent on GW (Chandrashekhar, Adiga, Lakshminarayana, Jagdeesha, & Nataraju, 1999). The quality of GW is as important as that of quantity because GW is the only source of drinking water in most of urban areas of India. The drinking water quality in Indian cities has been deteriorating in recent years mainly due to the high growth of population, unplanned growth of cities, mixed land use patterns, no proper sewage system, and poor disposal of the wastewater both from household as well as industrial activities. This has led to the pollution of underground water bed in and around Indian cities in general and Dehradun in particular. GW pollution is nothing but artificially induced degradation of natural GW quality. In contrast with surface water pollution, subsurface pollution is difficult to detect, is even more difficult to control, and may persist for years, decades, or even centuries (Todd, 1980). GW vulnerability is a function of the geologic setting of an area, as this largely controls the amount of time, i.e. the residence time of the GW that has passed since the water fell as rain,
infiltrated through the soil, reached the water table, and began following to its present location \((Prior, Boekhoff, Howes, Libra, & VanDorpe, 2003)\)\(^{195}\).

The agriculture sector accounts for between 90 to 95 per cent of surface and ground water in India, while industry and the domestic sector account for the remaining. Wide regional disparities in water availability also exist. Between 69 to 74 per cent of India’s rural population take their drinking water from protected sources, leaving an unserved population of 26 to 31 per cent. Between 91 to 93 per cent of India’s urban population take their drinking water from protected sources, leaving an unserved population of between seven to nine per cent. Water quality problems include Fluoride (66 million people pan India), excess Arsenic in ground water (nearly 13.8 million people pan India), varying iron levels, presence of nitrates and heavy metals, bacteriological contamination and salinity.

In the research work, many physicochemical parameters have been studied on multiple water sample collected across multiple seasons. The results have been presented considering drinking and domestic purposes as a main use of the water in the region.

While a very detailed analysis has been conducted and the detailed results have been presented in the Chapter 5, an attempt is being made to present some additional and important aspect to these results. The results have been compared to some standards as designated.
6.2 Drinking Water Standards

In India, CPCB has identified water quality requirements in terms of a few chemical characteristics, known as primary water quality criteria. The Indian regulations are governed by the Bureau of Indian Standards (BIS – formerly named the Indian Standards Institution, ISI). Further, Bureau of Indian Standards has recommended water quality parameters for different water use in the standard *IS 2296:1992* [Table 6.1].
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Drinking Water Source without conventional treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen (DO) mg/l, min</td>
<td>6</td>
</tr>
<tr>
<td>Biochemical Oxygen demand (BOD) mg/l, max</td>
<td>2</td>
</tr>
<tr>
<td>Total coliform organisms MPN/100ml, max</td>
<td>50</td>
</tr>
<tr>
<td>pH value</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Colour, Hazen units, max.</td>
<td>10</td>
</tr>
<tr>
<td>Odour</td>
<td>Un-objectionable</td>
</tr>
<tr>
<td>Taste</td>
<td>Tasteless</td>
</tr>
<tr>
<td>Total dissolved solids, mg/l, max.</td>
<td>500</td>
</tr>
<tr>
<td>Total hardness (as CaCO3), mg/l, max.</td>
<td>200</td>
</tr>
<tr>
<td>Calcium hardness (as CaCO3), mg/l, max.</td>
<td>200</td>
</tr>
<tr>
<td>Magnesium hardness (as CaCO3), mg/l, max.</td>
<td>200</td>
</tr>
<tr>
<td>Copper (as Cu), mg/l, max.</td>
<td>1.5</td>
</tr>
<tr>
<td>Iron (as Fe), mg/l, max.</td>
<td>0.3</td>
</tr>
<tr>
<td>Manganese (as Mn), mg/l, max.</td>
<td>0.5</td>
</tr>
<tr>
<td>Chlorides (as Cu), mg/l, max.</td>
<td>250</td>
</tr>
<tr>
<td>Sulphates (as SO4), mg/l, max.</td>
<td>400</td>
</tr>
<tr>
<td>Nitrates (as NO3), mg/l, max.</td>
<td>20</td>
</tr>
<tr>
<td>Florides (as F), mg/l, max.</td>
<td>1.5</td>
</tr>
<tr>
<td>Phenolic compounds (as C2H5OH), mg/l, max.</td>
<td>0.002</td>
</tr>
<tr>
<td>Mercury (as Hg), mg/l, max.</td>
<td>0.001</td>
</tr>
<tr>
<td>Cadmium (as Cd), mg/l, max.</td>
<td>0.01</td>
</tr>
<tr>
<td>Salenium (as Se), mg/l, max.</td>
<td>0.01</td>
</tr>
<tr>
<td>Arsenic (as As), mg/l, max.</td>
<td>0.05</td>
</tr>
<tr>
<td>Cyanide (as Pb), mg/l, max.</td>
<td>0.05</td>
</tr>
<tr>
<td>Lead (as Pb), mg/l, max.</td>
<td>0.1</td>
</tr>
<tr>
<td>Zinc (as Zn), mg/l, max.</td>
<td>15</td>
</tr>
<tr>
<td>Chromium (as Cr6+), mg/l, max.</td>
<td>0.05</td>
</tr>
<tr>
<td>Anionic detergents (as MBAS), mg/l, max.</td>
<td>0.2</td>
</tr>
<tr>
<td>Barium (as Ba), mg/l, max.</td>
<td>1</td>
</tr>
<tr>
<td>Free Ammonia (as N), mg/l, max</td>
<td>-</td>
</tr>
<tr>
<td>Electrical conductivity, micromhos/cm</td>
<td>-</td>
</tr>
<tr>
<td>Sodium absorption ratio, max</td>
<td>-</td>
</tr>
<tr>
<td>Boron, mg/l, max</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 6.1: Water Quality Standards in India (IS 2296:1992)*
6.3 Summary Gains

6.3.1 pH

Hydrogen ion concentration, commonly known as pH, should not be the only factor to be considered for drinking purposes. Drinking water with an elevated pH above 11 can cause skin, eye and mucous membrane irritation. On the opposite end of the scale, pH values below 4 also cause irritation due to the corrosive effects of low pH levels.

- All water samples, including one from Doiwala under bridge, all samples were well within pH range of 6.5 to 8.5 as defined in standards.
- The groundwater and surface water in and across areas of Song River seems to be fit into requirements of drinking water standards.
- Ground water samples were more alkaline (though marginally) as compared to surface water.

6.3.2 Hardness

Water is a good solvent and picks up impurities easily. Pure water is hence tasteless, colorless, and odourless and is often called the universal solvent. Water when combined with carbon dioxide forms very weak carbonic acid, and an even better solvent results. As water moves through soil and rock, it dissolves very small amounts of minerals and holds them in solution. Calcium and magnesium dissolved in water are the two most common minerals that make water "hard." The degree of hardness becomes greater as the calcium and magnesium content increases and is related to the concentration of multivalent cations dissolved in the water.

- Nearly 67% of water sample collected were found to be “chemically” hard with special emphasis on its temporal variation.
- The hardness was only marginal as compared to IS 2296:1992 standards. However, as per IS 10,500:1991 standards, it was still under permissible limits (600 mg/l).
• The hardness varied from season to season and only water collected during colder months was in prescribed hardness range.
• Almost all water samples whether, groundwater or surface water, treated municipal water or untreated river water, was found to be hard.

6.3.3 Calcium

Calcium dissolved in water is the common minerals that make water "hard." The degree of hardness becomes greater as the calcium content increases and is related to the concentration of multivalent cations dissolved in the water. Calcium precipitate soap, forming a curd which causes “bathtub ring” and dingy laundry (yellowing, greying, loss of brightness, and reduced life of washable fabrics), and feels unpleasant on the skin (red, itchy, or dry skin). To counteract these problems, synthetic detergents have been developed. These detergents have additives known as sequestering agents that “tie-up” the hardness ions so they cannot form the troublesome precipitates. Although synthetic detergents overcome these problems, both soap and detergent are wasted by hardness.

• 100% of water sample collected were found to have Calcium under desirable range
• The hardness varied from season to season and water collected in monsoons had higher Calcium concentration
• The calcium concentration was slightly higher in groundwater as compared to surface water
6.3.4 Magnesium

Magnesium dissolved in water is another common mineral that make water "hard." The degree of hardness will be greater as the magnesium content increases and is related to the concentration of multivalent cations dissolved in the water.

- 100% of water sample collected were found to have magnesium under desirable range
- The hardness varied from season to season and water collected in monsoons had higher magnesium concentration
- The magnesium concentration was marginally higher in groundwater as compared to surface water.

6.3.5 Total Dissolved Solids (TDS)

TDS represents the total concentration of dissolved substances in water and is made up of inorganic salts, as well as a small amount of organic matter. Common inorganic salts can be calcium, magnesium, potassium and sodium, which are all cations, and carbonates, nitrates, bicarbonates, chlorides and sulphates, which are all anions. Mineral springs contain water with high levels of dissolved solids, because the water has flowed through a region where the rocks have a high salt content. Agricultural and urban runoff can carry excess minerals into water sources, as can wastewater discharges, industrial wastewater and salt that is used to de-ice roads.

The data available indicates

- 100% sample that was chemically “hard” also had consistently higher TDS throughout the year
- 100% ground water sample had permissible limits of TDS
- 100% surface water sample had TDS well within range of defined standards

6.3.6 Biochemical Oxygen Demand (BOD)
Microorganisms such as bacteria are responsible for decomposing organic waste. When organic matter such as dead plants, leaves, grass clippings, manure, sewage, or even food waste is present in a water supply, the bacteria will begin the process of breaking down this waste. When this happens, much of the available dissolved oxygen is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. Biological Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose this waste. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline.

From the data collected and analysed, it was evident that the BOD values were well within range as per standards and all water samples were free from organic waste.

- Nearly all samples were within “close” range of BOD standard value
- One ground water site had slightly higher value of BOD across all seasons
- The sample with higher BOD was observed to have poor sanitation of human faecal material close by, indicating a lot of biological content leaching down t groundwater.
- The sample site also had poor waste management and a lot of synthetic waste as well as biological waste were dumped in close proximity (less than 10 meters).
6.3.7 Dissolved Oxygen

The oxygen supply in water comes from two sources

(a) Atmospheric diffusion and
(b) Photosynthetic activity of plants.

It is one of the most important and limiting parameter of water quality assessment, which maintain aquatic life. It regulates the metabolic process of aquatic organisms.

In the present study, the Dissolved Oxygen concentration in all the surface water samples ranges from 4.490 ppm - 9.596 ppm and in underground water samples it was undetected. The reason being that surface water is a natural source of water and is always saturated; however, underground water is not in direct influence of air around us.
6.4 Remedial Measures

Water is most essential but scarce resource in our country and water pollution is one of the biggest threats to the environment today. Presently the quality & the availability of the fresh water resources is the most pressing of the many environmental challenges on the national horizon. The stress on water resources is from multiple sources and the impacts can take diverse forms. Geometric increase in population coupled with rapid urbanization, industrialization and agricultural development has resulted in high impact on quality and quantity of water in our country. The situation warrants immediate need for redressal through radically improved water resource and water quality management strategies. The present document highlights the steps involved in preparation of a water quality management plan in a rational manner.

After studying the details of the present study area, I would like to suggest certain points, which may definitely help in reducing water pollution in one or the other way.

6.4.1 Awareness

There is an acute need of creating awareness should amongst the local population against pollution. Educating people and making them aware of the problem of water pollution can even control water pollution. Greater public awareness can make a positive difference. Posters should be pasted and free literature should be distributed depicting the harmful effects of pollution.

6.4.2 Conserve Soil

The link between soil and water is absolutely intrinsic. One of the most important ways in which soil conservation directly impacts water pollution is through erosion.
As soil is eroded by water, it transfers sediment from the land to the eroding body of water. Along with this sediment come a number of nutrients and chemicals that exist within the soil, which are then transferred to the water. The best way to combat soil erosion is to keep the banks of waterways well-covered with soil-retaining plants. Planting trees and certain herbaceous plants can have a significantly positive impact on the mitigation of soil erosion. **Some great plants to use when trying to control soil erosion are sage, buckwheat, Poplar and Eucalyptus.**

6.4.3 Dispose Toxic Chemicals Properly

There are various toxic chemicals that are used around our home on a daily basis. Chemicals such as ammonia, bleach, paint and many other cleaning products belong to a series of compounds known as “Volatile Organic Compounds” (VOCs). These chemicals are a major danger to waterways when they are not disposed of properly. **These chemicals or the containers that house the chemicals, should be disposed safely into local chemical recycling resources around the area. There are many local resources we can use to discover local disposal facilities.**

6.4.4 Proper Disposal of Solid Wastes

**Solid wastes** also contribute to a greater percentage in pollution and therefore its management is mandatory. The solid waste like plastic containers, polythene and other packing materials which are used and dumped as garbage should be disposed to land and not thrown in the open. **Dustbins should be provided to facilitate dumping of garbage.** Picking up litter wherever we find it is honestly the best, fastest way to do our part to stop this type of water pollution.
6.4.5 Selection of Technology

- Simpler technology should be adopted for sewage treatment.
- Sewage collection and treatment being primary responsibility of local authorities.
- Many times sewage can be found flowing in open drains in most of the cities, as these do not have full sewerage. Low strength sewage received from open drains is not ideal for anaerobic biological treatment as recovery of useful byproduct, biogas, is meager.
- Simpler option of treatment such as series of waste stabilization ponds may prove to be cost effective in such conditions.
- For low income housing colonies either two pit pour flush water seal latrines or a shallow sewer could a possible option.
- Co-operative group housing societies, multi storied housing complexes, big hotels etc. need to set up appropriate on-site waste water treatment facilities for recycling of waste water for gardening and other non-domestic uses to the extent feasible.
- Renovation of existing drainage system, which currently acts as open sewers.
- The options which are available for cost-effective and environmentally compatible sewage treatment include land treatment, waste stabilization ponds, constructed wetlands, duck-weed pond, aerated lagoon, rotating biological contractors, up-flow anaerobic sludge blanket system and root zone treatment.

6.4.6 Sanitation Schemes

Low cost sanitation schemes should be raised in the areas adjoining the rivers to reduce or prevent the flow of human waste into the river.

*Sulabh Shauchalays* and urinals should be provided near the bathing ghats and other public places.

6.4.7 Recycling/Reuse of Treated Industrial Waste and Resource Recovery
• The reuse and recycling of wastes for agricultural purpose would not only help to reduce the pollution and requirement of fresh water for such use but also would supplement the much needed nutrients and organic manure to the plants.

• The segregation of waste water streams may help in reducing waste water volume and waste strength and may help recycling and reuse of majority of waste streams.

• In pulp and paper industries, the paper mill wastewater is completely recycled into pulp mill by adopting fiber recovery system. It has helped to reduce the wastewater from 200 cum to 50 cum per ton of paper produced.

• Solid wastes should also be recovered and reprocessed by recycling. But before disposal or recovery, the wastage must be collected.

• Recycling of wastewater should be done to generate cheaper fuel gas and electricity.

• Sewage is very rich source of energy and may be used for the production of biogas. Production of energy from sewage will ensure a regular supply of power to run the sewage pumping and treatment plant.

6.4.8 Waste Minimization and Clean Technologies

It may be noted that by recycling techniques the waste concentrations may increase, however the total load remain the same. The concentration of waste strength would help the economical conversion of spent wash to bio fertilizer. Waste strength reduction can be achieved by Adopting in plant control measures such as reduction of spillages of wastes, elimination of process failures, use of proper equipment for handling and dry cleaning techniques etc. This is often termed as clean technologies; it does not add to the cost of production, in fact industry gains from it. Innovation in pollution prevention/waste minimization efforts on the part of the industries needs to be sternly promoted.
All organic wastes are best source of energy. A number of anaerobic technologies are now available for treatment of organic industrial effluents. Spent wash, black liquor (pulp mill), dairy effluents, sugar factory effluents and press mud etc. are some of the organic wastes tried for energy recovery. The energy recovery will incidentally solve the air pollution problem, as biogas is a cleaner fuel compared to bagasse, rice husk or coal. It is essential to introduce energy audit in all the industries so that cost-benefit ratio can be established in each case.

Bio-fertilizers are now prepared from organic rich wastes by admixing filler materials. Spent wash is converted to manure by addition of press mud, bagasse cillo, agricultural residues etc. In this technology the entire liquor effluent is converted into solid mass and it can be termed as “Zero-discharge” technology.

6.4.9 Avoid the Usage of Plastic

About 80% of the plastic in the water bodies came from the land. The ubiquitous nature of plastic in modern society could be attributed to a number of causes, but their versatility and affordability make them obvious choices for many. Using alternatives to plastics or using "less disposable" plastics whenever possible can have a surprising impact on ocean pollution.

a) Use Reusable Bags - Plastic bags in the water is a well-documented water pollutant. Keep this problem from getting worse by changing to reusable grocery bags whenever possible.

b) Opt for Glass Over Plastic - Instead of using plastic bins to store food, try opting for glass alternatives. Glass is not only more sustainable of an option than plastic, but it also doesn't retain food smells and is easier to clean.
Simply slowing down the rate of pollution can give the environment and scientists time to find long-term solutions to the very real problems of water pollution. If we do our part to prevent pollution in our area, then we will be helping to protect water for both ourselves and everything else that relies upon this precious resource.

One of the best ways to tackle this problem is by forming a principle called Polluter Pays Principle. This means that whoever causes pollution should have to pay to clean it up, one way or another. Polluter pays can operate in all kinds of ways. It could mean that tanker owners should have to take out insurance that covers the cost of oil spill clean ups, for e.g. it could also mean that shoppers should have to pay for their plastic grocery bags to encourage recycling and minimize waste. Or it could mean that factories that use rivers must have their water inlet pipes, so if they cause pollution they themselves are the first people to suffer. Ultimately, the polluter pays principle is designed to aware the people from polluting by making it less expensive for them to behave in an environmentally responsible way.

Some of the individual actions, which were practiced to reduce water pollution are-by using environmentally – friendly detergents, not pouring oil from drains, reducing pesticides, and so on. Community action could also be taken by helping out on beach cleans or litter picks to keep our rivers and seas that little bit cleaner. Strict actions, if any should also be taken regarding laws that will make pollution harder and the country less polluted.
6.5 Suggested Approach for Local Community

During the entire course of the study and with numerous interactions amongst the local residents it was ascertained that there is very little awareness about increasing water pollution and related problems. One of the reasons for this unawareness is that there had been not many problems reported related to the water borne diseases. Another bigger problem that was cited and proved with data results was that the municipally treated water needs more intense treatment. From one of the water sample that we collected from the government primary school had municipal water supply, however, the water did not meet the standards. On another note, the different water samples collected from different water sources were found to be hard with increased content of calcium and magnesium.

As such, it is an immediate need to create awareness as well as implement measures that will help the community at large to improve their health index. There are two big factors that should be considered before any mechanism is sought as a solution.

- Firstly, that the area of study does not falls into an urban civilization, it becomes important to bring those mechanisms that can be sourced locally. Implementing them for one time will not help the community at large, its regular maintenance and upkeep is equally important. Hence any mechanism that can be locally sourced engages the community to not just initiate and implement it, indeed maintain it forever.
- Secondly, there is no big history of water borne diseases; hence, there will be a definite reservation for the local community to adapt to a mechanism that brings an add-on to their living cost (both time and money). Therefore, a mechanism that can be implemented for larger community at once as well as does not bears a hefty cost of implementation or maintenance will need to be thought of for its successfulness.
Given the above two considerations, we interacted with many people and suggested following mechanisms which are less time consuming, low cost and easy to implement and maintain.

6.5.1 Sedimentation

The first step to purification is Sedimentation of surface water as naturally occurring phenomena with little structural and formal approach. For this, we suggested and helped the local authorities to build a small storage reservoir which could hold flowing water. It was built in a way that it was surrounded by a thick wall of small stones acting as a natural filter. The process of sedimentation allows settling flowing water for a few minutes to several hours. The clear water is decanted from the top of the container for use or to be poured into a second treatment process such as a filter. This process was really helpful, since the surface water was flowing through rocky bed and had a lot of crushed rock material. Refer figure 3.11 depicting the picture of the pond that was built on the side of flowing river.

6.5.2 Filtration

From sedimentation, we have proposed to build a hybrid sand filter which includes the slow sand filter with biological layer to remove any biological contaminant as well as rapid filter concept at the base to allow removal of fine particles. It uses sand media to remove impurities by straining and adsorption at a fairly high rate. This method is quite effective as it is helpful in removing most of suspended particles as well as associated pathogens.

6.5.3 Disinfection
The last in the process is the disinfection of underground water as well as surface water to destroy many pathogens. Many public water systems have to add a disinfectant to the water. The disinfectant must be present in all water found in the pipes that carry the water throughout the community. To prevent contamination with germs, the simplest method is to add a disinfectant, usually, either chlorine or chloramine.

6.5.4 Some Domestic Methods of Purification

As almost all the water samples found to be hard so there are some domestic hardness removal methods, can be applied easily at point of use. These methods are easy to operate and are very low cost for daily use.

6.5.4.1 Temporary Hardness

This can be easily removed by boiling the water or by lime softening process. The temporary hardness of water is removed by simple boiling the water. In this method the calcium and magnesium bicarbonate present in water and decomposes into calcium and magnesium carbonates, which are insoluble in water, hence they settle down and soft water is drained.

\[
\text{Ca(HCO}_3\text{)}_2 \rightarrow \text{CaCO}_3↓ + \text{CO}_2 + \text{H}_2\text{O} \\
\text{Mg(HCO}_3\text{)}_2 \rightarrow \text{MgCO}_3↓ + \text{CO}_2 + \text{H}_2\text{O}
\]
6.5.4.1 Permanent Hardness

Permanent hardness of water can be removed by the following ways:

(a) **By the use of soda:**

Soda removes both temporary and permanent hardness. It is also inexpensive and easy to use. This makes it the ideal substance for softening water in the home.

(b) **Other softening agents in the home:**

It is difficult for the housewife to be very precise in the use of soda and the water softened by soda may often contain an excess of it, which even if it is slight, may damage certain fabrics. Hence, other softening agents could be used. They are:

- **Soap:** Soap is used as a softening agent. However, the use of soap as a softening agent is extravagant on account of its high cost compared with soda.
- **Caustic soda:** It removes temporary hardness but reduces permanent hardness only when the lather is very slight.
- **Solution of Ammonia:** It may be used for softening water, however, since it is not possible to be very certain of the quantity to be used; this is not practicable for softening water.
- **Borax:** It is useful for softening water containing over 20% of hardness. Borax is usually used to reduce the alkalinity of soap solution rather than to soften water.
(c) **Base-Exchange Process:**

Base-Exchange process' is a chemical method by which, softening of permanent hardness in water can be done on a large scale or for household purposes. It is the most popular and effective means of softening hard water. It was discovered by Dr. Robert Gans, who found out the natural minerals called 'Zeolites', which is very effective in softening water,

The **Base-Exchange Process** includes the following procedures:

The water passes through specially prepared zeolite- a sodium compound, called base-exchange compound. it is has the property of being able to exchange its sodium base for another. When hard water passes through the zeolite, the hardening compounds of calcium and magnesium are caught up by the zeolite and become compounds of sodium. Since sodium salts in water do not precipitate out on heating or form soap curds the water is called 'soft'.

When a given quantity of water, determined by the size of the appliance, has been softened, the zeolite becomes depleted; having parted with all its sodium, but this can be remedied, as the substance has the property of being able to exchange its base again and to take back sodium in place of calcium and magnesium. This process is called 'regeneration'. Zeolite water softeners made for domestic use are either connected with the men water-supply or fixed on to a water tap.
6.6 Significance of the Study

The results of chemical analysis reveal that groundwater and surface water in the study area is chemically potable and suitable for domestic purpose i.e. drinking and households use, since most of the ionic concentrations and parameters are within the acceptable limits as per IS 2296:1992 guidelines, although some of the samples showed chemically higher values than the permissible limits. For example some of the constituents like TDS, Calcium, hardness; especially in surface water samples are higher than the permissible limits.

This study has provided evidence that water quality deterioration can and does occur between the points of supply and consumption. It has been shown that it can deteriorate to the extent that it is considered grossly polluted according to the classification system proposed by the National Sanitation Foundation (NSF) in 1970.

An important finding of the research is that water quality deterioration has been shown to happen regularly and frequently for surface water. No significant difference in the magnitude of water quality deterioration was observed as a result of season, neither did only certain households experience deterioration. This is significant as it suggest that there exists a constant and widespread problem in the handling of water between collection and consumption resulting in poor quality drinking-water. Stored water quality did appear to be source-dependent. Stored water that originated from the ground water sources were significantly better than those which came from river heads, irrigation canals or local ponds.

Another significant fact established with the study results very clearly states that almost all the surface water samples did not have appropriate water quality levels as specified by the National Sanitation Foundation (NSF) in
1970. Interestingly, the ground water quality was better in quality and was widely used for domestic purposes. The above fact can also be validated by looking at extreme values for nearly all parameters for one of the surface water site.

6.7 Limitations of the Study

The study was carried out in a limited geographical area. By the fact that water quality has a variation from geography to geography, the research and its outcome cannot be applied as a general rule of thumb. Further there are limitations associated with the nature of research, mode of research as well as data used for research (data collection and analysis).

- The transportation of sample collected and the preservation of sample to testing laboratory
- Contamination of sample due to inappropriate environmental conditions or improper packaging. Samples must be transported under appropriate conditions to the laboratory in clean containers and robust packaging.
- Incorrect labeling of sample
- Improper calibration of devices in testing laboratory
- The sample could be seasonally biased (specifically pre-monsoon and post-monsoon), hence we need to ensure appropriate timings to collect the sample