CHAPTER 1

GENERAL INTRODUCTION AND OBJECTIVES

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INTRODUCTION

1.1 PERAMBLE

Much of the ill health in the undeveloped countries is largely due to lack of safe drinking water. There can be no state of positive community health and well-being without safe water supply. After waterworks sanitation, cholera rate was reduced by 63.6 per cent, dysentery rate by 23.1 percent, typhoid fever death rate by 63.6 percent and the rate for diarrhoeal diseases by 42.7 percent in Uttar Pradesh (Park 1995). Therefore, money spent on good water supply is a sound investment which will pay huge dividends in improved health. Hence provision of safe community water supply is one of the most effective and permanent health technologies for improving the health of people. Water intended for human consumption should be not only "safe" but also "whole some". WHO defines safe and whole some water as water that is:

"Free from pathogenic agents, free from harmful chemical substances, pleasant to taste; and usable for domestic purposes".

Water is said to be contaminated when it contains infective and parasitic agents, poisonous chemical substances, industrial or other wastes or sewages (Park 1995). From the standpoint of public health, a daily supply of 150 to 200 litres of water per head is essential. As the quality of water is an important abiotic component for human survival, efforts are taken to consume water uncontaminated. There are three main sources for water supply viz: rain; surface water (Impounding reservoir, River, Streams, Tanks, Ponds and Lakes) and ground water (Wells and Springs).

In countries like India, public water supply is mostly from rivers or reservoirs and partly from wells. As these water resources have greater chances for contamination, it is imperative to analyze its quality and to prevent its contamination before consumption.

There are many reports on the contamination of water by infectious microbes. Water may contain microorganisms such as viruses, bacteria, algae, fungi, yeast, protozoa, rotifers, crustaceans, minute worms, etc. Potable water could be a source of various potentially infectious microorganisms that could be contracted by drinking, by inhaling droplet aerosol or by dermal exposure (Park, 1995). The best known potential pathogens are *Escherichia coli* and related Gram-negative species of faecal origin belonging to Enterobacteriaceae family, usually referred to "coliforms", which are commonly used as a sanitary indicator of potable water quality. Like *E.coli* other enteric bacilli belonged to the general, *Klebsiella,* and *Enterobacter* are *citrobacter, Hafnia* and *Serratia* are also called 'coliform' and the enumeration of coliforms is a more convenient standard of sanitary significance. The coliforms are indicators of contamination. (Collins et. al., 2001). Fecal streptococci are members of the genus Enterococcus and include *E.faecalis, E.faecium* and *E.durans* and sulphide reducing *Clostridium perfringers* also contaminate the water. Important agents of other water borne, infections comprise various genera of Gram-negative bacteria (*Legionella*, *Yersinia, Salmonella, Shigella, Campylobacter, Vibrio)* Mycobacteria, enteroviruses and intestinal protozoans (*Giardia, cryptosporidium)* (Stojek and Duttiewkz, 2006).

1.2 HAZARDS OF WATER POLLUTION

Man's health may be affected by the ingestion of contaminated water either directly or through food; and by the use of contaminated water for purposes of personal hygiene and recreation. The hazards of water pollution may be classified into two broad groups – biological and chemical.

1. 2.1 Biological hazards:

These comprise the classical water-borne diseases caused by the presence of an infective agent or an aquatic host in water. The water-borne diseases are listed in Table 1.(Park 1995)

Table 1. Water – borne diseases

1. Those caused by the presence of an infective agent :	
(a) Viral	Viral hepatitis, Poliomyelitis
(b) Bacterial	Cholera, typhoid, paratyphoid, bacillary dysentery, *E.coli* diarrhea and Rota Virus diarrhoea in infants
(c) Protozoan	Amoebiasis, giardiasis, cryptosporidiosis
(d)Helminthic	Roundworm, whipworm, threadworm, Hydatid disease.
(e)Leptospiral	Weil's disease
2. Those due to the presence of an aquatic host:	
(a) Cyclops	Guinea worm, Fish tape worm
(b) Snail	Schistosomiasis

1.2.2 Chemical Hazards:

Chemical pollutants of diverse nature derived from industrial and agricultural wastes are increasingly finding their way into public water supplies. These pollutants include detergent solvents, cyanides, heavy metals, pesticides, minerals and organic acids, nitrogenous substances, bleaching agents, dyes, pigments, sulfides, ammonia, toxic and biocidal organic compounds of great variety. Chemical pollutants may affect man's health not only directly, but also indirectly by accumulating in aquatic life(e.g. fish) which one used as human food. The present concern about chemical pollutants in water relates not so much as to their acute toxic effects on human health as to the possible long-term effects of low level exposure, which are often non-specific and difficult to detect. Further, some of the new pollutants are not easily removed by conventional water treatment or purification processes. In many developed countries where water-borne communicable disease have virtually disappeared, more attention is now being paid to chemical pollution.

While pollution seems to be an inevitable consequence of modern industrial technology, the problem, now is to determine the level of pollution that permits economic and social development without presenting hazards to health. The evaluation of the health effects of environmental pollutants is currently being carried out as part of the WHO Environmental Health Criteria Programme.

1.3 PURIFICATION OF WATER

Purification of water is of great importance in community medicine. It may be considered under two headings: (Park 1995)

1. Purification of water on a large scale
2. Purification of water on a small scale

1.3.1. Purification of water on a large scale

Water on large scale, such as an urban water supply, is purified in 3 main stages:

a) Storage

b) Filtration

c) Chlorination

(a) STORAGE

Water is drawn out from the source and impounded in natural or artificial reservoirs. Storage provides a reserve of water from which further pollution is excluded. As a result of storage, a very considerable amount of purification takes place. This is natural purification, and we may look at it from three points of view: **(a) Physical :** By mere storage, the quality of water improves. About 90 per cent of the suspended impurities settle down in 24 hours by gravity. The water becomes clearer. This allows penetration of light, and reduces the work of the filters,(WHO, 1976) **(b) Chemical :** Certain chemical changes also take place during storage. The aerobic bacteria oxidize the organic matter present in the water with the aid of dissolved oxygen. As a result, the content of free ammonia is reduced and rise in nitrates occurs. (WHO, 1970) **(c) Biological :** A tremendous drop takes place in bacterial count during storage. The pathogenic organisms gradually die out. It is found that when river water is stored, the total bacterial count drops by as much as 90 per cent in the first 5-7 days. This is one of the greatest benefits of storage. The optimum period of storage of river water is considered to be about 10-14 days. If the water is stored for long periods, there is likelihood of development of vegetable growths such as algae which impart a bad smell and colour to water.(Steel, 1960)

(b) FILTRATION

Filtration is the second stage in the purification of water, and quite an important stage because 98-99 per cent of the bacteria are removed by filtration, apart from other impurities. (Rajagopalan and Schiffman, 1974) Two types of filters are in use, the **"biological"** or **"slow sand"** filters and the "rapid sand" or "mechanical" filters.

(C) CHLORINATION

Chlorination is one of the greatest advances in water purification. It is supplement, not a substitute to sand filtration. Chlorine kills pathogenic bacteria, but it has no effect on spores and certain viruses (e.g. polio, viral hepatitis) except in high doses (Cox, 1964). Apart from its germicidal effect, chlorine has several important secondary properties of value in water treatment: it oxidizes iron, manganese and hydrogen sulphide; it destroys some taste and odour-producing constituents; it controls algae and slime organisms; and aids coagulation. (WHO, 1971)

When chlorine is added to water, there is formation of hydrochloric and hypochlorous acids. The hydrochloric acid is neutralized by the alkalinity of the water. The hypochlorous acid ionizes to from hydrogen ions and hypochlorite ions, as follows:-

$$H_2O + Cl_2 \rightarrow HCl + HOCl$$

$$HOCl \rightarrow H + OCl$$

The disinfecting action of chlorine is mainly due to the hypochlorous acid, and to a small extent due to the hypochlorite ions. The hypochlorous acid is the most effective form of chlorine for water disinfection. It is more effective (70-80 times) than the hypochlorite ion. Chlorine acts best as disinfectant when the pH of water around 7 because of the predominance of hypochlorous acid. When the pH value exceeds 8.5 it is unreliable as a disinfectant because about 90 percent of the hypochlorous acid gets ionized to hypochlorite ions. It is fortunate that most water have a pH value between 6-7.5. (Park, 1995)

Method of Chlorination

For disinfecting large bodies of water, chlorine is applied either as (1) chlorine gas (2) chloramines (3) perchloron. Chlorine gas is the first choice, because it is cheap, quick in action, efficient and easy to apply. Since chlorine gas is an irritant to the eyes and poisonous, a special equipment known as "chlorinating equipment" is required apply chlorine gas to water supplies.

While chlorine continues to be the most commonly used sterilizing agent because of its germicidal properties and the comparatively low cost and ease of application, its preeminence in water disinfection is being seriously challenged because of the discovery that chlorination of water can lead to the formation of many "halogenated compounds" some of which are either known or suspected carcinogens. As a result, many chlorine alternatives are received renewed interest. The include bromine, bromine-chloride, iodine and chlorine dioxide – but these do not seem to present a viable alternative to chlorine at the present time. Ozone is showing the greatest promise, and ultra-violet irradiation limited usefulness as complimentary agents for chlorine in water disinfection.(Park , 1995).

1.3.2. Purification of Water on a Small Scale : Household Purification of Water

Three methods are generally available for purifying water on an individual or domestic scale. These methods can be used singly or in combination.

(a) BOILING

Boiling is a satisfactory method of purifying water for household purposes. To be effective, the water must be brought to a "rolling boil" for 5 to 10 minutes. It kills all bacteria, spores, cysts and ova and yields sterilized water. Boiling also removes temporary hardness by driving off carbon dioxide and precipitating the calcium carbonate. The taste of water is altered, but this is harmless. While boiling is an excellent method of purifying water, it offer no "residual protection" against subsequent microbial contamination. Water should be boiled preferably in the same container in which it is to be stored to avoid contamination during storage.

(b) CHEMICAL DISINFECTION

1. **Bleaching Powder:**

Bleaching powder of chlorinated lime ($CaOCl_2$) is a white amorphous powder with a pungent smell of chlorine. When freshly made, it contain about 33 percent of "available chlorine". The principle in chlorination is to ensure a "free" residual chlorine of 0.5 mg/litre at the end of one hour contact. Highly polluted and turbid waters are not suited for direct chlorination.

2. **Chlorine Solution:**

Chlorine solution may be prepared from bleaching powder. If 4 kg of bleaching powder with 25 per cent available chlorine is mixed with 20 litres of water, it will give a 5 per cent solution of chlorine (Rajagopalan and Shiffman, 1974). Ready-made chlorine solutions in different strengths are also available in the market. Like bleaching powder, the chlorine solution is subject to losses on exposure to light or on prolonged storage.

3. **High Test Hypochlorite:**

High Test hypochlorite (HTH) or perchloron is a calcium compound which contains 60 to 70 percent available chlorine. It is more stable than bleaching powder and deteriorates much less on storage. Solutions prepared from HTH are also used for water disinfection. (Park , 1995).

4. **Chlorine Tablets:**

Under various trade names, tablets (viz., halazone tablets) are available in the market. They are quite good for disinfecting small quantities of water, but they are costly. The National Environmental Engineering Research Institute, Nagpur has formulated a new type of chlorine tablet which is 15 times better than ordinary halogen tablets. These tablets are manufactured in various strengths and are now available in plenty in the Indian market at a cheap rate. A single tablet of 0.5 g is sufficient to disinfect 20 litres of water. (WHO, 1970)

5. **Iodine:**

Iodine may be used for emergency disinfection of water. Two drops of 2 percent ethanol solution of iodine will suffice for one litre of clear water. A contact time of 20 to 30 minutes is needed for effective disinfection. Iodine does not react with ammonia or organic compounds to any great extent; hence it remains in its active molecular form, over a wide range of pH value and water conditions and persists longer than either chlorine or bromine. Iodine is unlikely to become a municipal water supply disinfectant in a broad sense. High costs and the fact that the element is physiologically active (thyroid activity) are its major disadvantages (Hoehn, 1976).

6. **Potassium Permanganate:**

Once widely used, it is no longer recommended for water disinfection. Although a powerful oxidizing agent, it is not a satisfactory agent for disinfecting water. It may kill cholera vibrios, but is of little use against other disease organisms. It has other draw-backs, too, such as altering the colour, smell and taste of water. (Cox, 1964).

(c) FILTRATION

Water can be purified on a small scale by filtering through ceramic filters such as Pasteur Chamberland filter, Berkefeld filter and "katadyn" filter. The essential part of a filter is the "candle" which is made of porcelain in the Chamberland type, and of kieselgurh or infusorial earth in the Berkefeld filter. In the Katadyn filter, the surface of the filter is coated with a silver catalyst so that bacteria coming contact with the surface are killed by the "oligodynamic" action of the silver ions, which are liberated into the water. Filter candles of the fine type usually remove bacteria found in drinking water, but not the filter-passing viruses. Filter candles are liable to be logged with impurities and bacteria. They should be cleaned by scrubbing with hard brush under running water and boiled at lease once a week. Only clean water should be used with ceramic filters. Although ceramic filter are effective in purifying water, they are not quite suitable for widespread use under Indian conditions.

1.3.3 Disinfection of wells:

Wells are the main source of water supply in the rural areas. The need often arises to disinfect them, sometimes on a mass scale, during epidemics of cholera and gastroenteritis. The most effective and cheapest method of disinfecting wells is by bleaching powder. *Potassium permanganate* should not be used, as it is not a satisfactory disinfecting agent.

For small scale household purification many commercial water purifier like Aquaguard is available in the market. These purifiers adopt technological advancements like ultraviolet radiation, nanofiltering units and reverse osmosis process. Such modern water treatment processes are also used for large scale packaging of commercial water bottles or water cans.

1.4 CRITERIA FOR WATER QUALITY

Water quality should always be considered in relation to the intended use of water – domestic, irrigation, industrial, fisheries, etc. Water quality indices for drinking water may be classified as follows:

(1) Physical Qualities :

The ordinary consumer judges the water quality by its physical characteristics. These are

(a) **Turbidity**: On aesthetic grounds, drinking water should be free from turbidity. Turbidity interferes with disinfection and microbiological determinations. The prescribed limit of turbidity in water is that is must be less than 5 units.

(b) **Colour :** Drinking water should be fee from colour which may be measured in units by the colorimeter. In drinking water, colour should be less that 5 units.

(c) **Odour :** Drinking water should have no disagreeable odour.

(d) **Taste :** Drinking water should be palatable and free from disagreeable taste.

To sum up, we cannot judge the quality of drinking water by physical characteristics alone. A detailed chemical and microbiological examination is also needed for complete assessment.

(2) Chemical Qualities :

a. **Chlorides :** All waters including rain water contain chlorides. Any excess over the normal range should arouse suspicion of water contamination. The standard prescribed for chloride is 200 mg/litre. The maximum permissible level is 600 mg/litre.

b. **Hardness :** The total hardness should not exceed 300 mg/litre.

c. **Free and Saline Ammonia :** This is an excellent indicator of sewage contamination of recent origin. Proteinaceous matter present in faecal matter is degraded and the resulting nitrogen is converted into ammonia by bacterial action. Free and saline ammonia should not exceed 0.05 mg/liter in drinking water.

d. **Albuminoid Ammonia:** It is a measure of the decomposable organic matter, yet to be oxidized. Underground water should not contain albuminoid ammonia. The albuminoid ammonia in potable waters should not exceed 0.1 mg per litre.

e. **Nitrites :** Nitrites should be zero in potable deep well waters, nitrites may be found as a result of reduction of nitrates by ferrous salts.

f. **Nitrates** : 'Nitrates tell the chemical story of the past history of water'. Their presence indicates an old contamination, provided nitrites are absent. Nitrates in water should not exceed 1 mg/l.

g. **Oxygen Absorbed** : The amount of oxygen absorbed by water is regarded as an approximate test of the amount of organic matter present in water. The oxygen absorbed at 37 deg.) in 3 hours not be less than 1 mg/l.

h. **Dissolved Oxygen** : This should not be less than 5 mg/l.

i. **Toxic Substances** : The presence of certain toxic substance in excess of prescribed limits may constitute substances include arsenic, cadmium, cyanide, lead, mercury and selenium. Although water may be pure from a chemical standpoint, chemical indicators cannot guarantee that the water is safe for human consumption because chemical indicators cannot be depended upon to detect minute quantities of sewage contamination. For this, bacteriological examination is needed. (Park , 1995)

(3) BACTERIOLOGICAL INDICATORS:

These are based on organisms indicative of faecal pollution, such as (a) *Escherichia coli*, and the coliform group as a whole, (b) *Faecal Streptococci*, and (c) *Clostridium perfringens.* Furthermore, examination for protozoa and other organisms (parasitic worms and larvae) is also recommended.

(a) Coliform organisms :

The "coliform" organisms include all aerobic and facultative anaerobic, gram-negative, non-sporing, motile and non-motile rods capable of fermenting lactose at 35 to 37 deg. in less than 48 hours. The coliform group includes both faecal and non-faecal organisms. Typical example of the faecal group is *E. coli* and of the non-faecal group, *Klebsiella aerogens.* From a practical point of view it is assumed that all coliforms are of faecal origin unless a non-faecal origin can be proved.

There are several reasons why coliform organisms are chosen as indicators of faecal pollution rather than the water-borne pathogens directly : (1) the coliform organisms are constantly present in great abundance in the human intestine. It is estimated that an average person excretes 200-400 billion of these organisms per day. These organisms are foreign to potable water, and hence their presence in water is looked upon as evidence of faecal contaminating. (2) they are easily detected by cultural methods – as small as one bacteria in 100 ml of water, whereas the methods for detecting the pathogenic organisms are complicated and time-consuming, (3) they survive longer than the pathogens, which tend to die out more rapidly than coliform bacilli, (4) the coliform bacilli have greater resistance to the forces of natural purification than the water borne pathogens. If the coliform organisms are present in a water sample, the assumption is the probable presence of intestinal pathogens. (ICMR, 1975)

(b) Faecal streptococci :

Faecal streptococci regularly occur in faeces, but in much smaller numbers than *E.coli*: The finding of faecal streptococci in water is regarded as important confirmatory evidence of recent faecal pollution of water, in doubtful cases. (Colins et.al., 2001)

(c) *Clostridium perfringens*:

They also occur regularly in faeces, though generally in much smaller numbers than *E.coli* : The spores are capable of surviving in water for a longer time than the other organisms of the coliform group and usually resist chlorination at the does normally used in waterworks practice. The presence of spores of *C. perfringens* in a natural water suggests that faecal contamination has occurred, and their presence, in the absence of the coliform group, suggests that faecal contamination occurred at some remote time.

1.5 WATER QUALITY STANDARD:

The quest for pure water dates back to antiquity. In modern times, it has led to the formulation of specific standards to provide a basis for judging the quality of water. These standards are exposure limited for bacteriological, viral, chemical and physical agents that have been adopted by governments or appropriate authorities and therefore have legal force. The purpose of standards is to minimize all the known health hazards, since it is obviously impossible to prevent all pollution. The WHO has published two sets of standards for drinking water – the International Standards (WHO, 1971) and the European Standards (WHO, 1970a). The International Standard set out minimal water quality requirements that are consistent with health protection and attainable by every country at present. The European Standards are higher than the minimal once specified in International Standards. The recommended standards in India are those set out the Indian Council of Medical Research (ICMR, 1975) based of International Standards. The standards of water quality are by no means static; they are constantly under review in the light of new knowledge.

The WHO 'International Standards for Drinking Water' (1971) relate to 5 water quality variables:

(a) Microbiological Pollutants

(b) Toxic Substances

(c) Specific substances that may affect health

(d) Characteristics affecting the acceptability of water

(e) Radioactive substances

(a) Microbiological Pollutants

These are the standards relating to the presence of bacteria and viruses in drinking water. The following guidelines are recommended by WHO (1996) for water in the distribution system. "Ideally all samples taken from the distribution system should be free from coliform organisms. In practice this standard is not always attainable, and the following standard for water collected in the distribution system is therefore recommended. (Park, 1995).

(1) Throughout any year, 95% per cent of samples should not contain any coliform organisms in 100 ml.

(2) No sample should contain *E.* coli in 100 ml

(3) No sample should contain more than 3 coliform organisms per 100 ml; and

(4) Coliform organisms should not be detectable in 100 ml. of any two consecutive samples"

The standard outlined above may not be attainable in the case of water derived from wells, bores and springs. In these waters, the coliform count should be less than 10 per 100 ml. Persistent failure to achieve this, particularly if *E.coli* is repeatedly found, should as a general rule, lead to condemnation of the supply.

Standards of Viral Quality

Several studies indicate that water free of faecal coliforms need not necessarily be free of viruses. Enteroviruses, retroviruses and adenoviruses have all been found in water.

The WHO Standards fix the limit for viruses at one plaque-forming unit (PFU) per litre. Newer recommendations are that faecal bacteriophages and enteropathogenic viruses should be completely absent (WHO, 1977a).

(b) Toxic Chemical Substances:

The presence of the substances cited below in excess of the concentrations quoted should constitute grounds for the rejection of the water as a public supply for domestic use:

Substance	Upper limit of Concentration (mg/litre)
Arsenic	0.05
Cadmium	0.005
Cyanide	0.05
Lead	0.05
Mercury	0.001
Selenium	0.01

(c) Specific chemical substances that may affect health:

(1) Fluorides :

Excess of fluorides in drinking water may give rise to dental flurosis in some children. When present in much higher concentrations, they may, eventually, cause endemic cumulative fluoride is also regarded as an essential constituent of drinking water, particularly with regard to the prevention of dental caries in children. If the fluoride concentration in the drinking water of a community is less than 0.5 mg/l, a high incidence of dental caries is likely to occur. Leading workers in India are of the opinion that 0.5 to 0.8 mg/l water fluoride is a safe limit.

(2) Nitrates :

Nitrates are dangerous to human health only in some infants under one year of age. The ingestion of water which contains nitrates in excess of 45 mg/l (as No_3) may give rise to infantile methaemoglobinaemia.

(3) Polynuclear aromatic hydrocarbons :

Some polynuclear aromatic hydrocarbons (PAH) are known to be carcinogenic. Their concentration, in general, should not exceed 0.2 mg/litre.

(d) Substances Affecting The Acceptability of Water:

The following criteria have been suggested by the WHO, 1977a in assessing the potability of water:

Substances Affecting The Acceptability of Water

S.No	Substance	Highest desirable level
1	Substance causing discolouration	5 units
2	Substance causing odours	objectionable
3	Substance causing tastes	objectionable
4	pH range	7.0 – 8.5
5	Total solids	500 mg/l
6	Total hardness	2 mg/l
7	Iron	0.1 mg/l
8	Manganese	0.05 mg/l
9	Copper	0.05 mg/l
10	Zinc	5.0 mg/l
11	Calcium	75 mg/l
12	Magnesium	30 mg/l
13	Sulphate (SO_4)	200 mg/l
14	Chloride	200 mg/l
15	Phenolic substances	0.001 mg/l

(e) Radioactive Substances:

Pollution of water supplies by radioactive substances represents an increasing hazard with regard to water quality. In radiological examination, radioactivity is expressed in Picocuries per liter (pCi/l). The WHO has proposed the following limits of radioactivity as acceptable :

Gross alpha activity 3 pci/l

Gross beta activity 30 pci/l

Surveillance of drinking water is essentially a health measure. It is intended to protect the public from water-borne disease.

1. 6 OPPORTUNISTIC BACTERIAL PATHOGENS IN WATER

Bacterial infection via water source cause infectious disease and impairs immune system. Many infections caused by bacteria that are commonly considered to be pathogen are inapparent or asymptomatic. Disease occurs if the bacteria or immunologic reactions to their presence cause sufficient harm to the person. Opportunistic pathogens are agents capable of causing disease only when the host's resistance is impaired (i.e when the person is "immuno compromised and debilitated. (Brooks et al., 1998). A compromised host is an individual who has one or more defects in their body's natural defence against microbial invaders. Consequently they are much more liable to suffer from severe and life threatening infections. Compromise can take two variety to forms, falling into two main groups 1) defects, accidental or intentional in body's innate immune defence mechanisms; and 2) deficiencies in the adaptive immune response. Compromised people can become infected with any pathogen able to infect the non-compromised individual, as well as with opportunistic pathogens microbes that are incapable of causing disease in a healthy person but able to infect when the host's defences are lowered often with total consequences. Common opportunistic bacterial pathogenic genera includes; *Listeria*, *Mycobacterium*, Pseudomonas, Gram negative *Enterobacteriaceae, Staphylococcus, Legionella Bacteroides* and *Nocardia.* Many of these opportunistic pathogens invade potable water source through land discharge with hospital wastes or through other human activities. Passive entry of these pathogens into immunocompromised persons may become fatal.

"Prevention is better than cure", it has become essential to zero down these opportunistic pathogens in the drinking water, bathing water and water that are used for other domestic purposes. If opportunistic bacteria contaminates water which human consumes, it may question the health and survival of immunocompromised hosts. To-day immunity suppression is quite high in human population due to many reasons. So "safe drinking water is a must" to-day and effort for getting "safe water" must be tried. There are many technologies to provide "safe water" and many commercial purifying units are available in the markets. Such water purifier use different mechanisms like ultraviolet radiation treatment, nanofilters, reverse osmosis etc. either singly or in combination. In the present investigation it has been planned to assess the microbial – (bacterial) quality of water that is supplied and ground water that people use at the Metrocity Chennai. In Chennai 7.5 millions of people use the public water supply system and ground water, so it is important to make them aware about the precautionary steps to purify water and to choose the commercial water purifier that do well.

In this direction the present work has been designed to monitor total and opportunistic bacterial load in the potable water supplied or taken from under ground in Chennai city and to evaluate the efficacy of various disinfectant or purifier mechanism so to select the most efficient water filter available in the market.

1.7 OBJECTIVES OF THE STUDY

Perusal of previous literature clearly indicates that bacteria, viruses and protozoans contamination in drinking water supplied by public water supply system or from ground water source pose a serious threat to human beings. In this context the present study has been designed to understand bacterial contamination in the drinking water supplied by Chennai Metropolitan city in India and in the ground water that are also commonly used for drinking purposes in the Chennai city. Chennai is one of the thickly populated cities in the world. Chennai metro water supply units provide drinking water from Porur lake after treating the water at

Kilpauk treatment units. Chennai citizens particularly people belonged to lower and middle classes often suffer with several waterborne illness. Several reports are available for gastrointestinal illness, jaundice, amoebiasis, giardiasis, cryptosporidiasis Leptospriosis etc in Chennai city (Jeyakumar and Ranjit Singh,2004). Hence, water sanitation is a matter of great concern in Chennai Metropolitan city, the capital of Tamilnadu state in India. Hence, the present study has been planned with following objectives.

1. Physio-chemical assessment of potable water supplied to households and ground water people use in Chennai Metropolitan city of India.
2. Continuous monitoring of total and opportunistic bacterial load in the drinking water supplied and in ground water for two years covering summer, winter and rainy seasons.
3. Evaluating the effectiveness of different water purification methods (viz; preheating, chlorination, iodination, ultraviolet radiation, ultra filtration, nanofiltration and reverse osmosis) with opportunistic microbial pathogens, using laboratory experimental model.
4. Evaluating the efficacy of the most popular brand of house hold water purification unit in point of use water supply.