Water Quality Studies of Eating Establishments of Patiala

A Dissertation

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Submitted

By

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DECLARATION

I, the undersigned, hereby declare that the research work presented in the M.Tech dissertation entitled **"Water Quality Studies of Eating Establishments of Patiala"** has been carried out by me under the supervision and guidance of **Mr. *K. S. Babu, Assistant Professor, School of Energy and Environment, Thapar University, Patiala.***

Further, I declare that no part of this Dissertation has been submitted for a degree or any other qualification of any other university or examining body in India/elsewhere.

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CERTIFICATE

This is to certify that dissertation entitled, "**Water Quality Studies of Eating Establishments of Patiala**" submitted by **Mr Ankit Gandotra** in partial fulfilment of the requirements for the award of **Masters in Technology** Degree in **Environmental Science & Technology** at **Thapar University**, **Patiala** is an authentic work carried out by his under our supervision and guidance.

To the best of our knowledge, the matter embodied in this dissertation has not been submitted to any other university/ institute for award of any other Degree or Diploma.

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ABSTRACT

A study on water quality provided at five eating establishments i.e. EE-1 (Jaggi Sweets), EE-2 (Gopal Sweets), EE-3 (Jaggi canteen TU campus), EE-4 (Dhaba at Adarsh Nagar), EE-5(Dhaba near TU Campus) of Patiala was conducted between Jan-May 2014. Water samples collected at monthly intervals was analysed for physico-chemical, bacteriological analysis. It was observed that water provided at EE-1 and EE-2 was superior in quality. Municipal surface water and ground water provided to customers at EE-4 and EE-5 were objectionable from solids, coliform levels point of view suggesting some essential treatment steps prior to serving.

CHAPTER 1
INTRODUCTION

1.1 GENERAL

. Water is vital natural resource, essential for many purposes like drinking, cooking and other domestic uses, industrial cooling, power generation, agriculture, transportation and waste disposal. The key to increase human productivity and long life is good quality water **[Urbansky and Magnuson, 2002].** The provision of good quality drinking water is regarded as an important means of improving health **[Moyo et al., 2004].**

Water forms about 75% of the matter of earth's crust. Water is divided in nature in different forms such as rain water, river water, spring water and mineral water. Over 98% of the fresh water on the earth lies below its surface. The remaining is present in lakes, rivers, streams and resources. Whether a surface water or ground water source, now-a-days, most of these are subjected to pollution. The discharge of effluents into water bodies and improper water management practices contributes significantly into the water pollution problems. The water quality is deteriorated in both industrialized as well as developing countries.

The use of water for drinking and other domestic purposes is generally conceded to be its highest and most essential. Water, in India and various Asian countries was never as unsafe as it is today due to the contamination from various sources. The inadequate water supply and poor sanitation services led to contamination of water supply through the input of sewage water into ground water. Except municipal water from some areas and during certain periods, water from most other sources is reported to contain coliform, in amounts several magnitudes higher than any standards permit.

The groundwater in contrast to surface water occur recharge from excess irrigation, seepage from canals, leakages from reservoirs etc. It is slowly moving in the lateral direction to some point of escape. Groundwater is generally treated pure than surface water. But water that looks colourless, odourless and tasteless may not be safe for consumption. It may contain some natural impurities or contaminants like magnesium, calcium, chloride, nitrate, arsenic, etc. Its quality also depends on depth of water table, quality of new water entering into it and chances of being polluted by municipal, industrial or agricultural wastes, etc.

1.2 WATER QUALITY SCENARIO IN INDIA

Rural India has more than 700 million people residing in about 1.42 million habitats spread over 15 diverse ecological regions. Meeting the drinking water needs of such a large population can be a daunting task. The non-uniformity in level of awareness, socio-economic development, education, poverty, practices and rituals and water availability add to the complexity of the task.

Despite an estimated total of Rs. 1,105 billion spent on providing safe drinking water since the First Five Year Plan was launched in 1951, lack of safe and secure drinking water continues to be a major hurdle and a national economic burden. Around 37.7 million Indians are affected by waterborne diseases annually; 1.5 million children are estimated to die of diarrhea alone and 73 million working days are lost due to waterborne disease each year. The resulting economic burden is estimated at $600 million a year **[Bordalo et al 2007]**.

While ‘traditional diseases’ such as diarrhea continue to take a heavy toll, 66 million Indians are at risk due to excess fluoride and 10 million due to excess arsenic in groundwater. In all, 1, 95,813 habitations in the country are affected by poor water quality. It is clear that the large investments have not yielded comparable improvements in health and other socio-economic indicators.

1.2.1Water Resources and Utilisation

- India has 16 per cent of the world’s population and four per cent of its fresh water resources.
- Estimates indicate that surface and ground water availability is around 1,869 billion cubic metres (BCM). Of this, 40 per cent is not available for use due to geological and topographical reasons.
- Around 4,000 BCM of fresh water is available due to precipitation in the form of rain and snow, most of which returns to the seas via rivers.
- Ninety two per cent groundwater extracted is used in the agricultural sector, five and three per cent respectively for industrial and domestic sector.
- Eight nine per cent of surface water use is for agricultural sector and two per cent and nine per cent respectively are used by the industrial and domestic sector.

While on the one hand the pressures of development are changing the distribution of water in the country, access to adequate water has been cited as the primary factor responsible for limiting development. The average availability of water remains more or less fixed according to the natural hydrological cycle but the per capita availability reduces steadily due to an increasing population.

- In 1955, the per capita availability was 5,300 cubic metres (cu.m) per person per year, which came down to 2,200 cu. m in 1996.
- It is expected that by around 2020, India will be a 'water stressed' state with per capita availability declining to 1600 cu m/person/year.

1.3 WATER QUALITY STANDARDS

Water quality is the chemical and physical characterization of water. We have different water quality criteria for drinking water and wastewater. The primary bases for such characterization are parameters which relate to safety of human contact (drinking water).

Contaminants that may be in untreated water include microorganisms such as viruses and bacteria; inorganic contaminants such as salts and metals; pesticides and herbicides; organic chemical contaminants from industrial processes and petroleum (gasoline); and radioactive contaminants. Water quality depends on the local geology and ecosystem, as well as human activities such as sewage dispersion, industrial pollution, and overuse (which may lower the level of the water).

Drinking water quality standards describes the quality parameters set for drinking water. Despite the truism that every human on this planet needs drinking water to survive and that water may contain many harmful constituents, there are no universally recognized and accepted international standards for drinking water. Even where standards do exist, and are applied, the permitted concentration of individual constituents may vary by as much as ten times from one set of standards to another.

Many developed countries specify standards to be applied in their own country. In Europe, this includes the European Drinking Water Directive and in the USA the United States Environmental Protection Agency (EPA) establishes standards as required by the Safe Drinking Water Act. For countries without a legislative or administrative framework for such standards, the World Health Organization (WHO) publishes guidelines on the standards that should be achieved.

EPA prescribes regulations that limit the amount of certain contaminants in the water provided by public water systems for tap water. Food and Drug Administration (FDA) regulations establish limits for contaminants in bottled water that must provide the same protection for public health. Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of these contaminants does not necessarily indicate that the water poses a health risk.

Water quality is determined by the characteristics contributing to water such as pH, turbidity, hardness, total suspended and dissolved solids, micro-organisms as fecal coliform (MPN), chlorides, fluorides etc; water quality criteria is decided by keeping the purpose of use whereas water quality standards are established by keeping what could be achieved.

1.4 SCENARIO OF PUNJAB

The state of Punjab, located in the North region of the country, has a geographic area of 50,362 km^2, which is 1.5 % of the country's geographic area. In 2001, Punjab has a total human population of 24.29 million (2.4 % of the country's population). The rural population is 66.1 % and urban population is 33.9 % and the population density of 482 persons per sq.km.

Punjab is one of the richest states in India, having experienced the highest rates of economic growth in the country until recently. Primary production forms the basis for its strong economy, with agricultural crop husbandry experiencing phenomenal growth since the introduction of the Green Revolution in the mid 1960s. Punjab has enormous water resources. Its fertile land is irrigated by both surface and ground water. The intensive use of ground water for irrigation and other human needs has resulted in the declining of water levels. The water is also exploited in other sector such as industry.

1.5 STATUS OF WATER AT PATIALA

Patiala district of Punjab state lies between 29^0 49' to 30^0 40' north latitudes and 75^0 58' to 76^0 48' east longitudes. Total geographical area of the district is 3290 sq.km. The Patiala district is divided into five sub-divisions (tehsils) namely Patiala, Nabha, Ghanaur, Rajpura and

Samana comprising eight-community development blocks viz. Patiala, nabha, Sanaur, Bhunerheri, rajpura, ghanaur, samana and Patran for the purpose of administration. The district headquarter, Patiala town falls in Patiala Tehsil. Occupied by Indo-Gangetic alluvial plains of Quaternary age, Patiala falls in Ghaggar basin. The groundwater occurs in alluvium formations comprising fine to coarse sand. In the shallow aquifer groundwater occurs under unconfined/water table conditions, whereas in deeper aquifer, semi-confined/confined conditions exist. The overall flow of ground water is from northeast to south-west direction. The drinking water supply is mainly through groundwater. The shortfall in water supply is met by installing submersible/hand pumps by public individually. The shallow tube-wells tap unconfined aquifer varies from 20 to 70m.

Patiala city has a population around 4-5 lakhs. Besides, the good educational facilities, it has wide commercial activities associated with it. Patialavis in addition to taking home food, greatly depend on outside eating and drinking establishments for fulfilling requirements. Visiting the establishments in evenings with families and taking snacks, dinner is a common scenario. Hundreds of eating and drinking establishments varying from minor Dhaba to major units have been set up in the city.

1.6 DEFINING THE RESEARCH PROBLEM

Quality of water used at eating and drinking establishments is of concern from the health point of view of customers. Water is collected from different sources, stored and used for food preparation, serving etc. The water may receive contamination during collection, storage and serving thus affecting the health. The water supplied in Patiala is treated, although a few city dwellers extract the water directly from underground. No studies have been performed in this connection yet. Hence an attempt is made to study water quality at the eating and drinking establishments located at different parts of city. The study was performed during Jan-May 2014.

1.6.1 **Work elements included**

- Selection of establishments after a preliminary survey at Patiala.
- Study of source, storage and serving practices of water.
- Quality analysis i.e. physical, chemical, biological of water.
- Proposing feasibility treatment options for wholesomeness of water.

CHAPTER 2

REVIEW OF LITERATURE

Water is used extensively for domestic, agriculture and industrial purposes. Quality of water required for meeting a purpose varies and in turn quality of water generated is influenced by the beneficial utility. For example, For drinking water. Parameters such as fluoride, coliform, metals are considered; in agriculture pH, dissolved solids for water are looked at. The literature collected from E-sources, magazines and journals are presented.

Pradhan et al., (2003) investigated the quality of drinking water used by the communities and their awareness regarding water quality and water borne diseases in Bungamati Locality in Kathmandu Valley, Nepal. The observation indicated that the factors responsible for contaminating drinking water at source points included lack of protection and proper treatment of water, leakage in pipe distribution system, intermittent supply of water, poor drainage system and poor environment surrounding of water sources. The communities are unaware of the quality of water they use. Incidence of water borne diseases appears to be the common health problem among the households. It is found more serious during the dry summer than the other seasons.

Sajidu (2007) collected drinking water samples from boreholes and pipes at 23 sampling sites, mostly villages, for fluoride and other water physicochemical parameters during dry and rainy seasons of 2004 and 2005 respectively. Fluoride endemic areas were identified as those villages around Mtubwi F.P School and Liwonde L.E.A School. This finding was supported by the prevalence of a high proportion of dental fluorosis in standard 3 and 4 pupils in these two schools.

Rahi (2009) worked on several physicochemical & biological parameters of water in Patiala. He observed the average values of pH 7.45, slightly alkaline nature. It suggests turbidity less than 1.0NTU for good drinking water as excessive turbidity protect pathogens from disinfectants, and also stimulate the growth of bacteria. Optimum values of hardness (234 to 389 mg/L) were obtained indicating the difficulty in cleaning utensils and washing clothes, but were below the permissible limit (600mg/L). The alkalinity indicating presence of carbonates, bicarbonates and hydroxide, showed range of 240-394 mg/L. Average value of chloride was 43 mg/L. Bacterial analysis at 22°C is indicative of the bacteria found within the environment.

The results revealed that the sewage water deteriorates the water quality and more care is required to maintain the quality of drinking water.

Ramirez et al (2010) investigated the source of microbiological and chemical contamination of groundwater in Cuautla-Yautepec aquifer in Mexico and observed a gradient for dissolved solids according to altitude; the concentrations of dissolved solids increased in wells with lower altitudes.

Raju *et al*., (1992) Analysed ground water samples during post monsoon and pre monsoon in upper Gunjana Eru river basin of Cuddapah district, Andhra Pradesh to assess the quality of water. The inequality was due to agricultural and domestic activities through infiltration and percolation during monsoon.

Patel et al. (1994) described the quality of ground water in rural areas of the Rourkela Industrial Complex. The study was carried out in a two year period. 21 physicochemical and 11 metallic parameters were analyzed in the ground water samples from 14 rural areas of this industrial complex and values obtained were compared with standards prescribed by World Health Organization, to assess the quality of water for drinking purposes. Analysis of results showed that ground water is perfectly fit for drinking.

Naidu et al., (1997).studied the water quality parameters in the coastal towns of Andhra Pradesh to assess their suitability for domestic and other needs .The results clearly indicated that some towns were polluted either by industrial waste water or by sewage. Drinking water samples were analyzed in Gandhi gram, Tamil Nadu by **Mary et al., (1997)** to estimate the concentration of fluoride, iron, hardness and bacterial population. In most of the cases the concentration of iron, total hardness and bacterial count were found to be beyond tolerance limits. Water Quality survey of Rohtas district of Bihar was conducted by **Ray et al., (2000)**. Samples were collected from different sources and analyzed. Two hundred and nine samples were collected from 196 villages. Results of water quality survey identified the problems in respect of high iron, manganese, fluoride, nitrate and brackishness of water in the district. **Rao (2001)** discusses about the toxicity of fluoride in ground water of Chittoor district of Andhra Pradesh.

Guruprasad (2003) examined the physico-chemical and bacteriological quality of groundwater in Tadepalli mandal of Guntur district. Investigation was aimed at assessing the impact of pollutants due to agriculture and human activities on water quality. The results indicated high levels of nutrient load and pollution in the hand pumps. Ground water with higher concentration of magnesium causes laxative effect to human beings and excess fluoride causes severe bone fluorosis as determined by **Mishra et al., (2003)**

All physico-chemical parameters recorded in the study by **Sivagurunathan et al., (2005**) in sethiyathope area in Cuddalore dist. showed higher values in summer season than in winter season, except fluoride content in ground water. Water samples were collected from wells, springs and rivers/streams during pre and post monsoon seasons to evaluate drinking water quality on the basis of BIS and irrigation water quality by **Rai (2005).** The study showed alkaline nature of surface and ground water. Calcium and magnesium are dominating cations and bicarbonate is major anion in the study area. At some locations the concentration of TDS, Mg, Ca, total hardness, Fe, Mn and Cr exceeded the limits set up for drinking purposes.

Tatawat and Chandel studied the groundwater quality of Jaipur city in **2006** due to rapid urbanization and industrialization. Eleven ground water samples were collected from different hand pumps to study the chemical parameter, such as pH, EC, Total Hardness Calcium, Magnesium, Sodium, Potassium, Carbonate, Bicarbonate, Sulphate, and Chloride, with the help of standard method of APHA during premonsoon.

Gadhave (2008) presented the paper to find quality of water samples and to find out the magnitude of health problems in industrial area of Shrirampur. The natural quality of ground water tends to be degraded by human activities. Six sampling points were selected for the study. The parameters studied were pH, Total hardness, Chlorides, Sulphates, Calcium and the ion concentrations.

Hiremath et al., (2011) analyzed seasonally the physico-chemical parameters of 36 samples from different sources in Karnataka. Parameters like pH, conductivity, TDS, total hardness, sulfate and chloride were studied and compared with WHO standards. The investigation revealed that the water quality of sources and some of the water samples are unfit for drinking.

Parihar et al., 2012 evaluated the physico-chemical & microbiological characteristics of 16 drinking water samples in Gwalior, M.P. Electrical conductivity, TDS, total aerobic microbial count & MPN were maximum in one sample. pH hardness were observed higher in 3 samples. Enteric pathogen E.coli and Enterobacter were found in 9 samples. No coliforms were observed in 7 samples. These results showed that maximum samples were not suitable for drinking purpose.

Narasimha et al., (2012) assessed the physico-chemical parameters of drinking water (pH, conductivity, TDS, total hardness and chloride). The chloride content in 27.7% of groundwater samples is above the WHO standards. The physicochemical quality of drinking water varied drastically among different sites. 39% of samples exceeded the desirable limit of WHO standards.

Sharma (2012) studied the groundwater quality of Malwa region and showed the parameters exceeding the WHO and ICMR limits.

Rompre et al., (2001) enumerated and detected approaches for coliform in drinking water. The aim of their study was to examine methods currently in use or which can be proposed for the monitoring of coliform in drinking water. Approved traditional methods for coliform detection include the multiple –tube fermentation and the membrane filter technique using different specific media & incubation conditions.

Nicolaisen, (2002) worked on spiral wound membrane technology as a means of producing various qualities of water from surface water, well water & seawater. Spiral wound elements span the four commonly defined membrane technologies, which are microfiltration (0.01 microns), Ultrafiltration (500-100000 Da), nanofiltration (100-500Da), and Reverse osmosis (up to 100Da).

Meunier et al., (2006) studied the implications of sequential use of UV & Ozone for drinking water quality .The formation of bromated levels exceeding the drinking water standard of 10 μGl^{-1} imposed the reduction of ozone doses used in the treatment of drinking water.

Bordalo and Joanna (2007) conducted a pilot study during the wet season on Bolama Island (West Africa). At the onset of the wet season, diarrhoea represented specific level of all medical cases, 92.5% of which were children aged <15 yrs. They also suggested inexpensive steps to reduce the fecal contamination & control the pH in order to increase the potability of the well water.

Pritchard et al., (2007) conducted studies in Blantyre, Chiradzulu and Mulanje districts in Malawi to determine the biologiocal, chemical and physical drinking water quality from shallow wells. Chemical analyses were within the drinking water guideline and variations during seasons were insignificant. pH values were within the guidelines in the dry season except for Mulanje district where on average 45% of the wells had pH values below the lower limit of 6.0. Turbidity values were within the guideline for all covered wells in the dry season, while about 22% had turbidity values greater than the guideline of 25 NTU in the wet season. Total coliform and faecal coliform values in the wet season were much higher than those in the dry season.

Dorea (2008) made an attempt on Emergency water treatment approaches relying on coagulation varying from centralized modular and portable “kits” to “point of use” or “household” interventions. Types of coagulant employed in emergencies are presented along with issues such as process control, sludge production and management, ease of use and coagulant residuals in finished waters.

Karavoltsos et al., (2008) evaluated comprehensively the quality of drinking water in regions of Greece. The physicochemical parameters investigated were conductivity, total dissolved solids, and pH as well as related to the treatment of drinking water such as chloride, potassium, calcium, magnesium and sodium, heavy metals (Cd, Cu, Mg, Pb, Cr, Ni), anions and cations such as fluoride, bromide , nitrates , nitrites ,ammonium , sulphates and phosphates , as well as dissolved organic carbon.

Verbanets et al., (2008) studied the decentralized systems for potable water & the potential of membrane technology. Most water –quality problems were due to hygiene factors & pathogens. A range of decentralised systems including thermal &/or UV methods, physical removal & chemical treatment were available.

Arnal et al., (2009) worked on Ultrafiltration as an alternative membrane technology to obtain safe drinking water from surface water. Ultrafiltration represents an effective alternative to obtain safe drinking water, due to its ability to remove microbiological contamination from surface water.

Srinivasan et al., (2009) worked on treatment on per chlorate in drinking water because of its extremely low concentrations and strong resistance to most treatment technologies, per chlorate become one of the biggest challenges currently being faced by drinking water industry.

Greenlee et al., (2009) made an attempt on reverse osmosis membrane technology that has been developed on desalination plants worldwide. Both brackish water & seawater reverse osmosis plants of innovative design would allow greater use of desalination for inland and rural communities, while providing more affordable water for large coastal cities.

Parmar and Parmar (2010) developed water quality index using six water quality parameters - DO ,BOD, MPN, TURBIDITY, TDS and pH measured at five different stations along the river basin to see variance in water quality from excellent to marginal range.

Viswanathan et al., (2009) worked on fate of fluoride ion in drinking water. The objective of this study was to predict optimal fluoride level in drinking water for fluoride endemic Malwa region of Punjab. The consumption of drinking water containing more than 0.65mg/l of fluoride can raise the total fluoride intake per day more than 4 mg, which is the optimum fluoride dose level recommended for adults.

Manja et al., made a field test for the detection of faecal pollution in drinking water". A comprehensive field investigation in several parts of India has revealed that the presence of coliform in drinking water is associated with hydrogen sulphide-producing organisms. The new test showed good agreement with the standard most probable number (MPN) test. It proved highly successful in the field when it was used to detect faecal pollution and to monitor water quality during an outbreak of water-borne hepatitis A infection in the city of Gwalior.

Belkacem et al., (2006) made two stages RO module for groundwater treatment in the beverage industry. Turbidity removal, fecal coliform destruction was noticed during the operation.

Wagh and Srivastava (2006) have shown the statistical approach of groundwater contamination by municipal sewage. Presence of pathogens is objectionable and decreases the potability of water. The role of Nutrients and pathogens in water has been discussed by **Follett and Follett,** (2001) and **Puech et al,** (2001).

Thakur et al., (2003) reported that fecal and sewage contamination was the causes of high bacterial loads in the water. Water from surface sources was found to be more polluted than ground sources.

Krishna et al., (2005), studied the physico-chemical and bacteriological parameters of drinking bore well and sewage samples in Sivakasi, India. Most of the physico-chemical characteristics of drinking and bore well water were within the ISI permissible levels. However, in water samples from all sites, bacterial count exceeded the recommended permissible level of WHO. Introduction of sewage into the drinking and bore well water was the main reason for the bacterial contamination.

Mittal et al., (1997) evaluated the groundwater quality of Patiala, Punjab. Higher concentrations of various inorganic ions were observed in the sewage. Leaching of contaminants from the sewers was the only cause of groundwater pollution.

Nogueira et al., (2003) evaluated the microbiological quality of treated and untreated water samples and found that the highest number of water samples contaminated by total coliforms (83%) and fecal coliforms (48%) were found in untreated waters. Among the treated water samples examined, coliform bacteria were found in 171 of the 1,033 sampling reservoirs. More than 17% of the treated potable water contained coliforms TC and FC were seasonally influenced in treated water. It was observed that warm weather had high percentage of contaminated samples. TC & FC positive samples declined with decrease in temperature.

Zamaxaka (2004) collected water samples from rural area from Cape Province, South Africa and studied physico-chemical and microbiological quality. The water used for domestic purpose is having high ionic and total coliform counts.

Natasha et al., (2005) assessed the microbiological quality of 125 drinking water samples in South Africa. The frequency of isolation of E. coli, Salmonella, Shigella and C.jejuni was 70%, 5%, 5% and 2% respectively. The total coliform ranged from 4.9×10^2 to 5.8×10^3 CFU/100ml, faecal coliform from 2.6×10^2 to 3.7×10^3CFU/100ml and fecal streptococci from 3.1×10^3 to 5.8×10^3 CFU/100ml in tap water stored in household containers.

Tambekar et al., (2006), studied contamination in drinking water in Amravati city which is due to improper handling, storage and serving which leads to the serious waterborne diseases. A total of 340 water samples were analysed for bacterial contamination, out of them, 69% were non potable by MPN method, 73.2% by multiple tube fermentation method indicating presence of E.coli and 18% fecal coliform presence.

Fred (2006) reported that 60 million people are estimated to have been poisoned by well - water contaminated by excessive fluoride, which dissolved from granite rocks. The effects are particularly evident in the bone deformations of children. Larger problems are anticipated in countries such as China, Ethiopia and Uzbekistan. Although helpful for dental health in low dosage, fluoride in large amount interferes with bone formation.

Karikari and Asare (2006), conducted water quality assessment in Ghana and identified human, animal agricultural activities as the main sources of pollution. The dominance of chloride over sulphate was probably due to household effluents, fertilizer used and other anthropogenic activities.

Abaas et al., (2007) determined the bacteriological analysis of hand pump water in Pakistan for faecal contamination. He found that 67% of the samples were positive for faecal streptococci. The minimum most probable number (MPN) was 3 and maximum was >2400 for faecal streptococci. Of the 54 samples of faecal streptococci strains, 72.2% were identified as enterococci.

Sharma et al., (1994) studied the groundwater sources adjacent to the sewage channel in Gwalior, Madhya Pradesh. About 69% of the total samples, especially bore well water, collected were found to be contaminated. The possible reason may be excessive extraction of groundwater through bore wells. Besides this contaminated water might also mix with potable water in the bore holes

Thakur et al., (2003) reported that faecal and sewage contamination was the causes of high bacterial loads in the water. Water from surface sources was found to be more polluted than ground sources.

Kumar et al., (2005) studied the physico-chemical and microbiological parameters of Patiala. They studied different localities water samples viz. municipal supply water, submersible pumps water and hand pump water. They indicated that alkalinity, Hardness and TDS as per BIS Specifications are very high. Also municipal supply water had the poor microbiological quality. The value of coliform was very high.

Mohapatra et al., (2009), indicated that Fluoride in drinking water has a profound effect on teeth and bones. Up to a small level (1–1.5 mg/L) this strengthens the enamel. Concentrations in the range of 1.5–4 mg/L result in dental fluorosis whereas with prolonged exposure at still higher fluoride concentrations (4–10 mg/L) dental fluorosis progresses to skeletal fluorosis. High fluoride concentrations in groundwater, up to more than 30 mg/L, occur widely, in many parts of the world. This review article is aimed at providing precise information on efforts made by various researchers in the field of fluoride removal for drinking water. The fluoride removal has been broadly divided in two sections dealing with membrane and adsorption techniques. Under the membrane techniques reverse osmosis, nanofiltration, dialysis and electro-dialysis have been discussed. Adsorption, which is a conventional technique, deals with adsorbents such as: alumina/aluminium based materials, clays and soils, calcium based minerals, synthetic compounds and carbon based materials. Studies on fluoride removal from aqueous solutions using various reversed zeolites, modified zeolites and ion exchange resins based on cross-linked polystyrene are reviewed.

Kaur (2012) analysed the performance of pureit, Kent RO and Aqua fresh and indicated that their behaviour was not same during the study period. The variations were attributed to operation and maintenance taken up by residents.

The information quoted above indicates the parameters of concern in water for different utilities, sources and extent of pollution etc. It is worthy to agree that the information collected doesn’t relate directly to sanitation aspects of eating and drinking establishments.

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the materials used and the methodologies employed during the study.

- Chemicals-chemicals used were of analytical grade with sufficient purity.
- Instruments – All instruments with accuracy procured from authorised dealers were employed for measurement of characteristics of sample.
- Calibration Curve – They were prepared from stock solution before estimating unknown parameters (Fluoride) & were used throughout the study.

3.1 SAMPLING

3.3.1 Selection of sources: A preliminary survey was made in Patiala at different locations. By accessibility, maintenance, convenience five eating establishments (EE) were selected for the study purpose. Two of them were major, one was medium and two more were minor types. Water was collected at fortnight intervals from medium and minor establishments but once in a month from major type of establishments (due to technical problems) during the study period from Jan – May 2014.

Table 3.1 Sources of Eating Establishments and types of water use

S.NO.	Name	Source of water use
1	Jaggi Sweets, 22 No. phatak	RO treated water
2	Gopal Sweets, Leela bhawan	RO treated water
3	Jaggi Canteen TU campus	RO treated water
4	Dhabha, Adarsh Nagar	Municipal tap water
5	Dhabha near TU campus	Hand pump water

3.2 Sample collection and preservation – Samples of tap water, Hand pump water and RO treated water collected from eating establishments were representative and were transported to laboratory and preserved at 4^0C refrigeration prior to the analysis. Acid rinsed polyethylene (Jerry Cans) containers of 2Ltr capacity were used in sample collection.

3.3 Characterization of samples

Samples of tap water, hand pump water and RO treated waters collected were analysed for various characteristics by using standard methods for examination of water and wastewater, (APHA, 1999).

3.3.1 Physical Analysis

Turbidity

Turbidity of sample was measured by Turbidometer (Nephlometer) using optical properties of light.

Total Suspended Solids

TSS is solids in water which can be trapped by a filter. High concentrations of suspended solids can cause many problems for stream health and aquatic life.

$$mg/L\ total\ suspended\ solids = \frac{\{(A - B) \times 1000\}}{sample\ volume, mL}$$

Where,

A = weight of filter paper after filtration (filter disk + solids retained)

B = weight of filter disk before filtration

Total Dissolved Solids

TDS are solids in water that can pass through a filter (usually with a pore size of 0.45 micrometers). TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. TDS represents the amount of ions in the water. Water with high TDS often has a bad taste and/or high water hardness, and could result in a laxative effect. The U.S. Environmental Protection Agency sets a secondary standard of 500 mg/L TDS in drinking water.

$$mg/Ltotal\ dissolved\ solids = \frac{(A - B) \times 1000}{ml\ of\ sample}$$

Where,

A = weight of dish and residue

B = weight of dish before filtration

3.3.2 Chemical Analysis

pH

The pH of samples was measured by pH meter, after proper calibration with buffer solution of pH 4.0, 7.0, 9.3.

ALKALINIY

Alkalinity is primarily a way of measuring the acid neutralising capacity of water. In other words, it is ability to maintain relatively constant pH. The possibility to maintain constant pH is due to hydroxyl, carbonate and bicarbonate ions present in water. The ability of natural water to act as a buffer is controlled in part by the amount of calcium and carbonate ions in the solution. It is estimated by titrating the sample with N/50 H_2SO_4.

$$Total\ alkalinity(\frac{mg}{L}) = \frac{Vol\ of\ acid\ consumed \times 1000}{ml\ of\ water}$$

Total Hardness

Hardness represents the concentration of calcium ($Ca^{2+)}$ and magnesium (Mg^{2+}) ions. Waters with high hardness values are referred to as "hard," while those with low hardness values are "soft". Because hardness varies greatly due to differences in geology, there are no general standards for hardness. Waters with a total hardness in the range of 0 to 60 mg/L are termed soft; from 60 to 120 mg/L moderately hard; from 120 to 180 mg/L hard; and above 180 mg/L very hard. EDTA titration method was used in the presence of EBT indicator.

$$\frac{mg}{L} Total\ Hardness = \frac{[Vol\ of\ EDTA\ used \times N \times 50 \times 1000]}{volume\ of\ sample\ taken}$$

Chloride

Chlorides are widely distributed as salts of calcium, sodium and potassium in water and waste water. In potable water, the salty taste produced by chloride concentrations is variable and dependent upon the chemical composition of water. The major taste producing salts in water are sodium chloride and calcium chloride. The salty taste is due to chloride anions and associated cations. Chlorides are estimated using Argentometric volumetric titration method

$$\frac{mg}{L} chlorides = \frac{[(A - B) \times N \times 35.45 \times 1000]}{vol\ of\ sample,\ mL}$$

Where,

A = vol of $AgNo_3$ used for sample

B = vol of $AgNo_3$ for blank

Fluoride

Fluoride estimation was done by colorimetric method. This is done by the fading of zirconium-SPADNS dye complex on the addition of fluoride ions. Fluoride ions form a stronger complex $(ZrF_6)^{-2}$ with zirconium ions, and consequently are able to displace the dye from the complex. The diminishing absorbance of the complex can be measured calorimetrically at 570nm.

3.3.3 Biological Analysis

MPN TEST

The standard test for the coliform group was carried out by the multiple tube fermentation technique. Bacterial density was given by the formula given or the table using the number of positive tubes in each dilution.

CHAPTER 4

RESULTS AND DISCUSSION

The results of the study performed and discussion on results are presented in this chapter.

Table 4.1 Characteristics of Eating Establishments Studied:

S.No	Name	No. of users per day	Major Activities	Source of Water	Type of Treatment	General Observations
1)	EE-1	500-750	Preparing and serving meals & selling own bakery products & sweets.	Bore well water	RO System (Cxl Titon Purifiers)	Clean food service practices, well maintained RO; Sanitized utensils; Ventilated premises.
2)	EE-2	250-400	Preparing and serving meals & selling own bakery products & sweets.	Bore well water	RO System (Shakti RO purifiers)	Clean food service practices, well maintained RO; Sanitized utensils; Ventilated premises.
3)	EE-3	150-200	Preparing and serving meals.	Ground water atTU Campus.	RO system	Moderately good food service practices, outdated RO system.
4)	EE-4	70-120	Preparing and serving meals	Municipal Tap Water	No Treatment	Unsatisfactory methods of food preparation;

						Handling & service of food is improper; poor sanitation in premise, kitchen; flies & dust nuisance.
5)	EE-5	120- 150	Preparing and serving meals, sweets etc.	Hand pump Water	No Treatment	Unsatisfactory methods of food preparation; Handling & service of food is improper; poor sanitation in premise, kitchen; flies & dust nuisance.

4.1 Water Quality Analysis at Eating Establishments

Samples of water collected from different Eating Establishments were analysed for physico-chemical and biological parameters. The discussion on analysis results (Table 4.2 – table 4.6) is made in this section.

pH is a measurement of intensity of H^+ ions and its value is 7 at neutral condition. pH less or more than 7 is representation of acidic and alkaline nature. For drinking water pH should be between 6.5 -7.5. pH is considered necessarily in various treatment steps such as disinfection, corrosion control, alum coagulation etc.

Alkalinity measures the neutralising capacity of an acid. In drinking water bicarbonate, carbonate is common in causing alkalinity. Hardness is caused due to salts of Ca^+2, Mg^{+2} and principally due to anions, bicarbonates, chlorides and sulphates etc, although hardness is not objection to drink, its presence in industries is serious. Turbidity is the resistance offered by a sample to the passage of light through it. It is contributed by suspended solids and colloidal solids and presence of it is objectionable in filter operation and efficiency of disinfection. The drinking water is permitted to contain turbidity value 0.5-5 NTU.

Suspended solids are immiscible and picked up during erosions of rocks. They affect the passage of light and bring sedimentation of water bodies. Dissolved solid enters into water due to solubility action and make water saline. In drinking water, dissolved solids of level 500 mg/l is permitted, chlorides, form of dissolved solids, and enter into water through domestic sewage, oceanic water, excess pumping. Fluoride, an active anion, is harmful to human beings in causing dental problems, crippling etc. fluorosis is endemic by nature and the severity enhances with time of exposure and type of population. Coliforms, an indicator of presence of pathogens, are established by most probable number (MPN) test in the laboratory. Ideally, MPN count in treated water should be nil.

Table 4.2: <u>Parametric Analysis at EE-1</u>

Parameter	Jan	Feb	March	April	May
pH	6.85	6.78	6.92	6.82	6.76
Alkalinity(mg/l)	25	30	27	29	32
Total Hardness(mg/l)	22	28	18	20	25
Turbidity(NTU)	0.12	0.10	0.09	0.11	0.08
TSS (mg/l)	8	6	6	7	9
TDS (mg/l)	155	165	160	172	164
Chloride(mg/l)	25	32	34	35	26
Fluoride (mg/l)	0.15	0.12	0.11	0.17	0.15
MPN	Nil	Nil	Nil	Nil	Nil

At the EE-1, the borewell water sample obtained during the study was from A RO treated. The alkalinity ranged from 27-35 mg/l of $CaCO_3$ with a mean value of 28.6 mg/l. TSS and TDS were in acceptable range with mean values of 7.2 mg/l and 163.2 mg/l respectively. Chlorides and Fluorides were found within the prescribed limits of WHO. No coliform bacteria were found in the samples. Many of the parameters analysed indicated the drinking water of good quality. (Table 4.2)

Table 4.3: Parametric Analysis at EE-2

Parameter	Jan	Feb	March	April	May
pH	6.71	6.62	6.77	6.65	6.82
Alkalinity	25	27	23	28	32
Total Hardness(mg/l)	40	37	35	30	28
Turbidity	0.09	0.11	0.10	0.12	0.13
TSS (mg/l)	5	7	9	6	7
TDS (mg/l)	160	154	155	170	164
Chloride (mg/l)	29	31	27	34	25
Fluoride (mg/l)	0.16	0.13	0.15	0.12	0.08
MPN	Nil	Nil	Nil	Nil	Nil

Water analysis at EE-2 showed that pH was in slightly acidic and alkalinity ranged from 25 to 37 mg/l of $CaCO_3$. Hardness varied from 28 to 40 mg/l of $CaCO_3$. TSS and TDS were 6.6 mg/l and 160.6 mg/l respectively. Chlorides were 29.2 mg/l and fluorides were 0.128 mg/l on average where as no coliform bacteria was found. The samples represented good quality as similar to that of EE-1 (Table 4.3).

Table 4.4: <u>Parametric Analysis at EE-3</u>

Parameter	Jan	Feb	March	April	May
pH	7.22	7.42	7.15	7.45	7.33
Alkalinity	37	41	35	38	44
Total Hardness(mg/l)	25	20	28	32	29
Turbidity(NTU)	0.12	0.14	0.11	0.15	0.13
TSS (mg/l)	7	9	10	6	7
TDS (mg/l)	165	162	170	176	185
Chloride (mg/l)	36	39	50	45	40
Fluoride (mg/l)	0.15	0.19	0.16	0.18	0.14
MPN	8	4	5	5	Nil

For the water analysis at EE-3, pH of the samples was little above than neutral range where as alkalinity ranged from 35 to 44 mg/l of $CaCO_3$. Water was not found hard indicating no Ca or Mg salts were present. TSS and TDS ranged average 8 and 162.6 mg/l. Chlorides and Fluorides with average 38.4 mg/l and 0.164 mg/l respectively were within the limits (Table 4.4). A coliform count between 5-8/100 ml is a matter of concern.

Table 4.5: <u>Parametric Analysis at EE-4</u>

Parameter	Jan		Feb		March		April		May	
pH	7.06	7.10	7.12	7.20	7.05	7.15	7.22	7.24	7.15	7.20
Alkalinity (mg/l)	138	148	155	158	152	137	145	141	130	135
Total Hardness(mg/l)	150	154	178	168	165	182	172	185	171	165
Turbidity	0.17	0.19	0.22	0.24	0.16	0.20	0.19	0.24	0.22	0.26
TSS (mg/l)	14	15	12	18	20	19	22	16	15	23
TDS (mg/l)	300	310	314	328	325	329	337	320	290	297
Chloride (mg/l)	72	65	58	56	58	65	62	69	53	57
Fluoride (mg/l)	0.69	0.65	0.66	0.64	0.62	0.67	0.59	0.57	0.68	0.65
MPN (/100ml)	40	65	74	68	41	76	58	43	78	76

The sample was derived at fortnight through municipal taps at EE-4. For the surface water, pH was slightly above the neutral range. Alkalinity was in range of 130-158 mg/l of $CaCO_3$. Hardness varied from time to time and went up to high values of 185 mg/l of $CaCO_3$. TSS and TDS were averaging 14.9 mg/l and 315 mg/l respectively. Chlorides and Fluorides were in permissible limit. Coliform bacteria were found in a high range of 40-76/100 ml. This water requires a great attention before its use for drinking purpose (Table 4.5).

Table 4.6: <u>Parametric Analysis at EE-5</u>

Parameter	Jan		Feb		March		April		May	
pH	7.64	7.72	7.68	7.75	7.69	7.74	7.83	7.79	7.75	7.82
Alkalinity	352	365	325	320	315	330	342	369	366	342
Total Hardness(mg/l)	285	296	290	305	283	298	300	305	287	285
Turbidity(NTU)	0.85	0.75	0.77	0.84	0.89	0.82	0.79	0.80	0.95	1.42
TSS (mg/l)	25	24	26	23	27	22	17	19	20	23
TDS (mg/l)	474	486	460	463	478	470	471	475	480	485
Chloride (mg/l)	45	62	64	72	63	69	57	62	68	66
Fluoride (mg/l)	0.32	0.27	0.33	0.36	0.28	0.25	0.29	0.30	0.32	0.28
MPN (/100ml)	55	60	77	80	100	75	95	105	85	80

When water resources at EE-5 were analyzed, it gave the following results. For the borewell water, pH was little higher than neutral range. Alkalinity was high as compared to other samples where as this sample was harder in nature. TSS was higher ranging from 19 to 27 mg/l and TDS were much higher (460-485 mg/l). Chlorides were not found compared to that of other EEs; fluorides value ranges from 0.25-0.33 mg/l. MPN count also increased ranging from 55 to 105/100 ml. This water sample requires greater attention prior to providing for drinking purposes.

4.2 Comparative Analysis of water quality at Eating Establishments

The average values of the water quality parameters during the study period were compared for the eating establishments and represented from Figure 4.1-4.9.

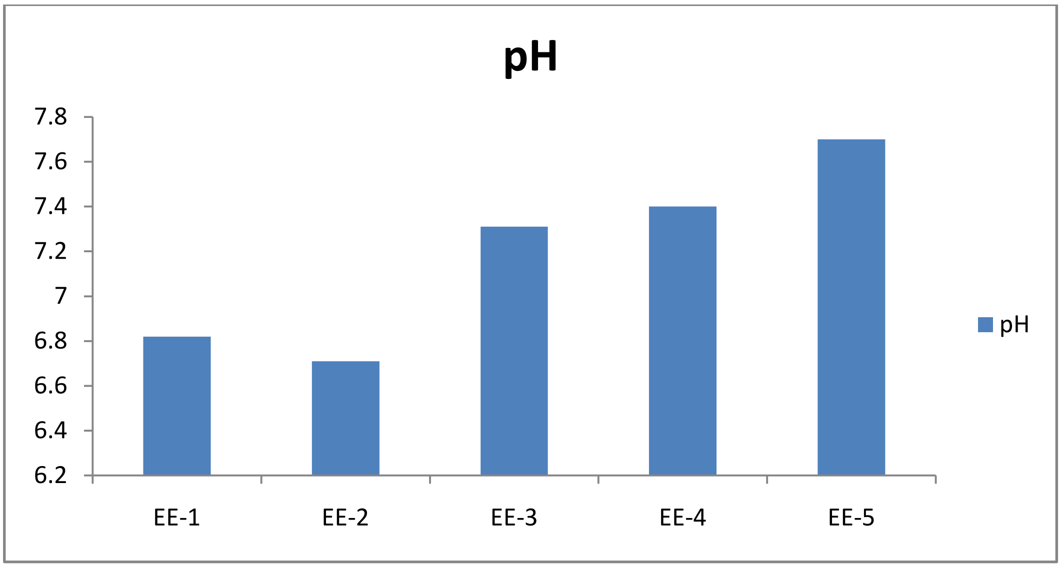

Figure 4.1: Variation in pH of water

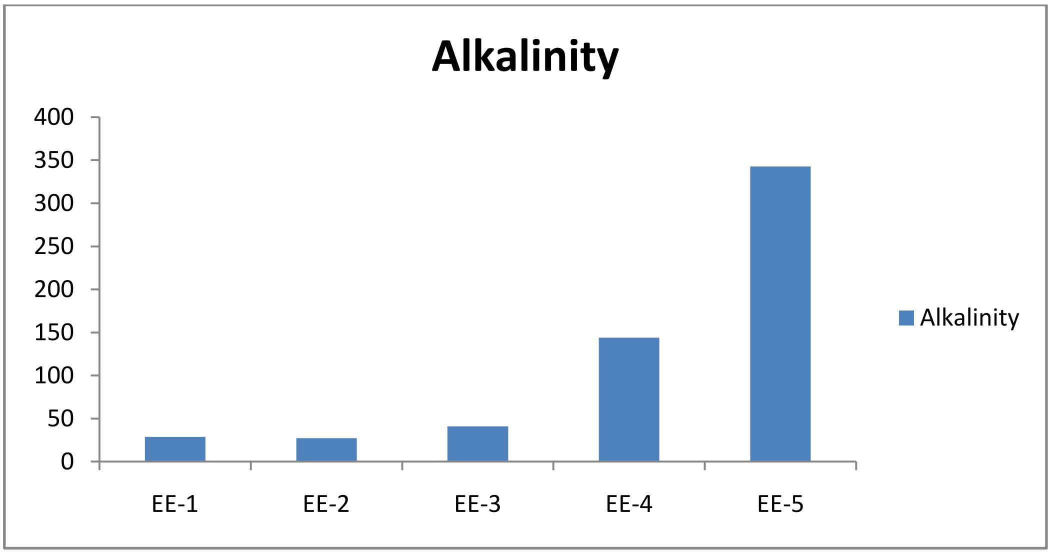

Figure 4.2: Variation in Alkalinity of water

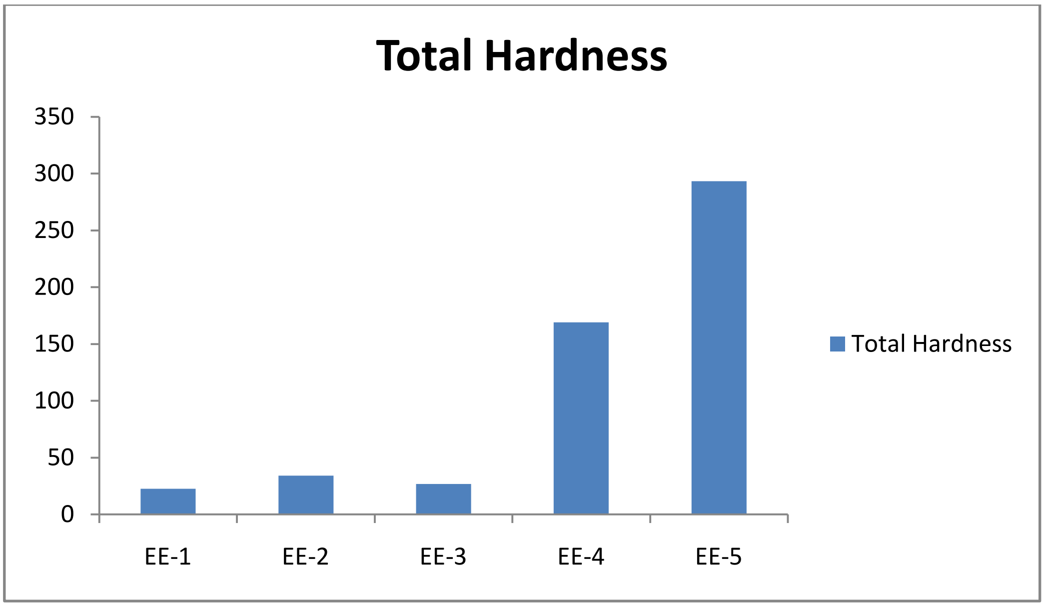

Figure 4.3: Variation in Total Hardness of water

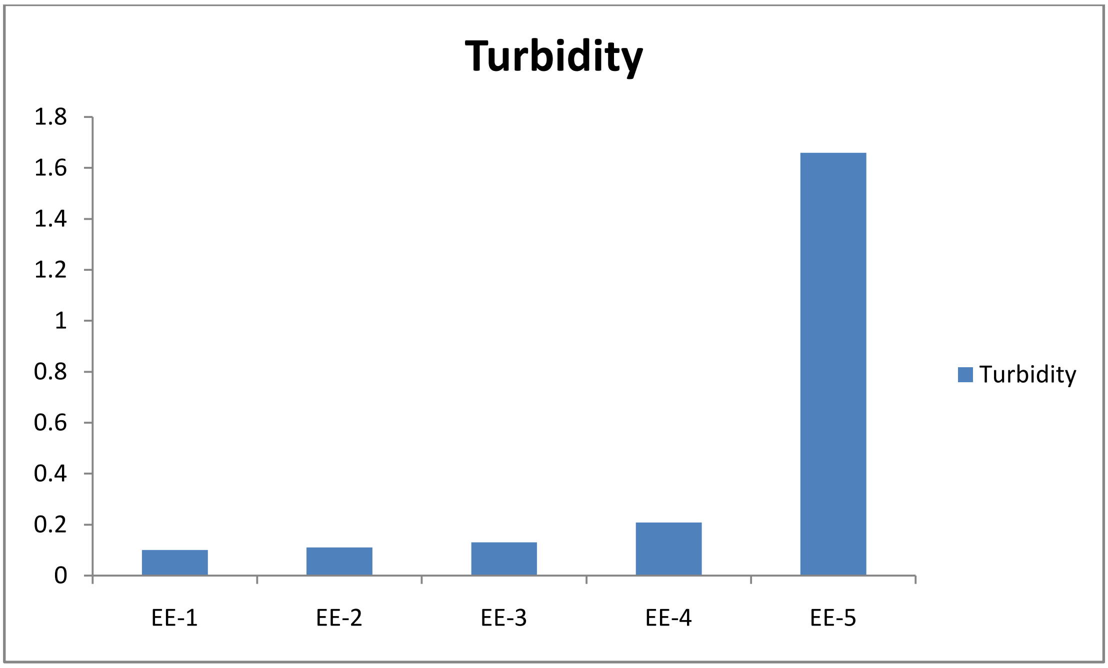

Figure 4.4: Variation in Turbidity of water

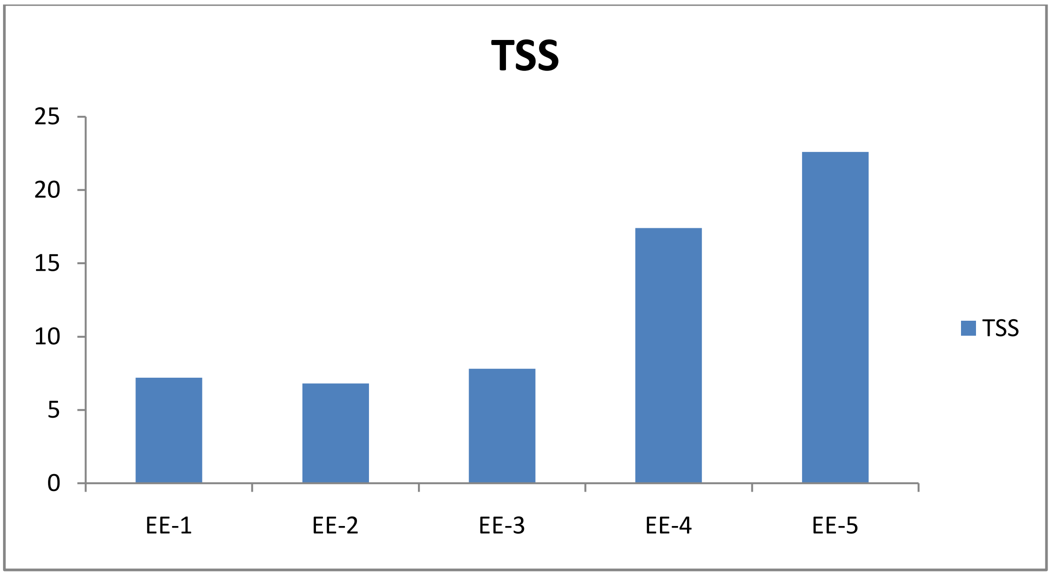

Figure 4.5: Variation in TSS of water

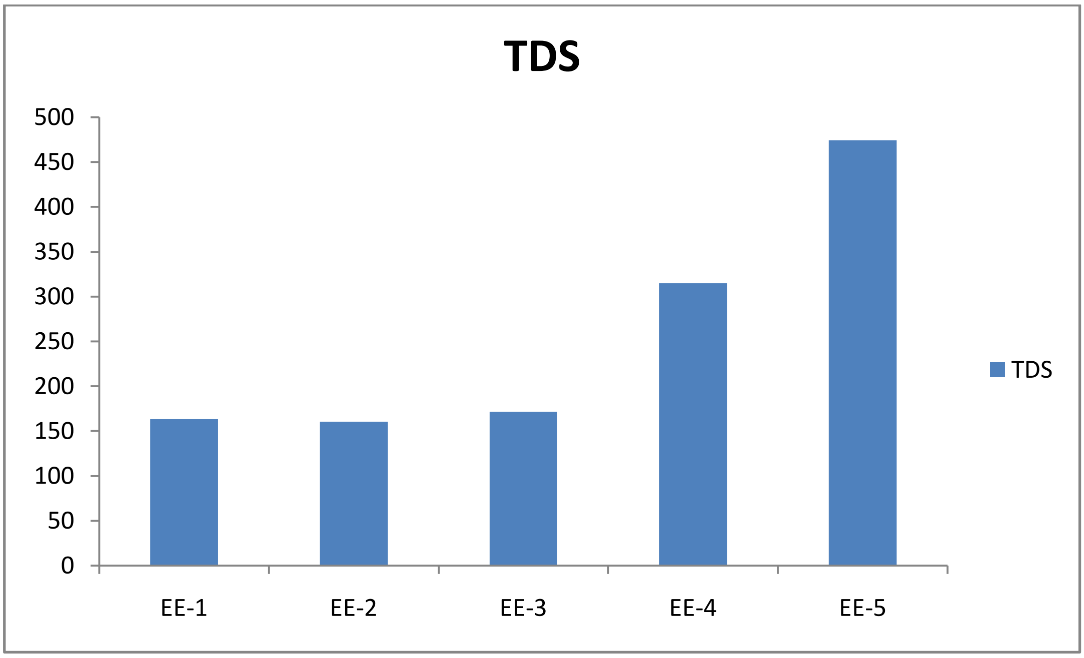

Figure 4.6: Variation of TDS in water

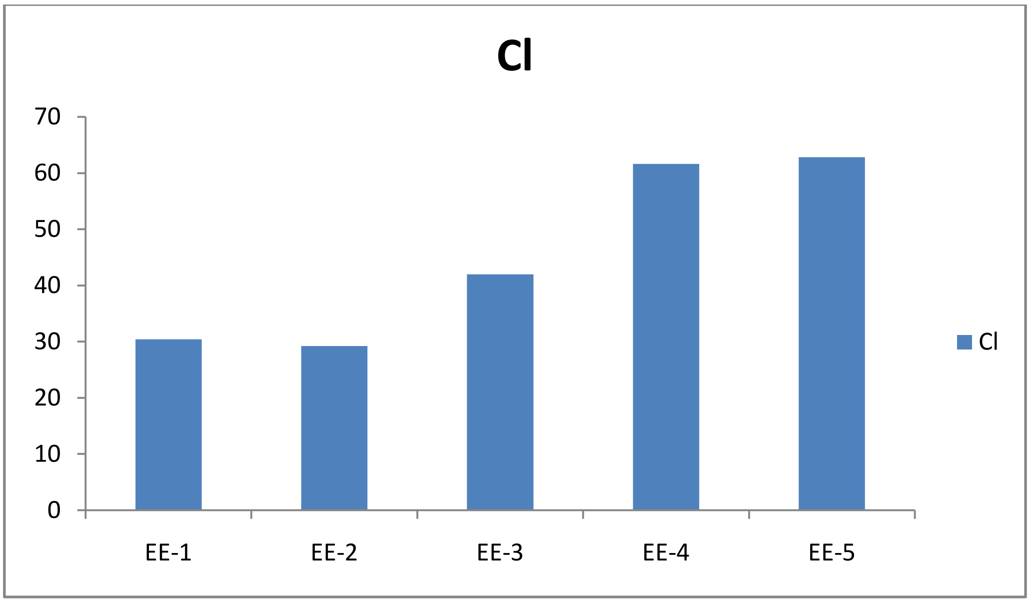

Figure 4.7: Variation in Chloride of water

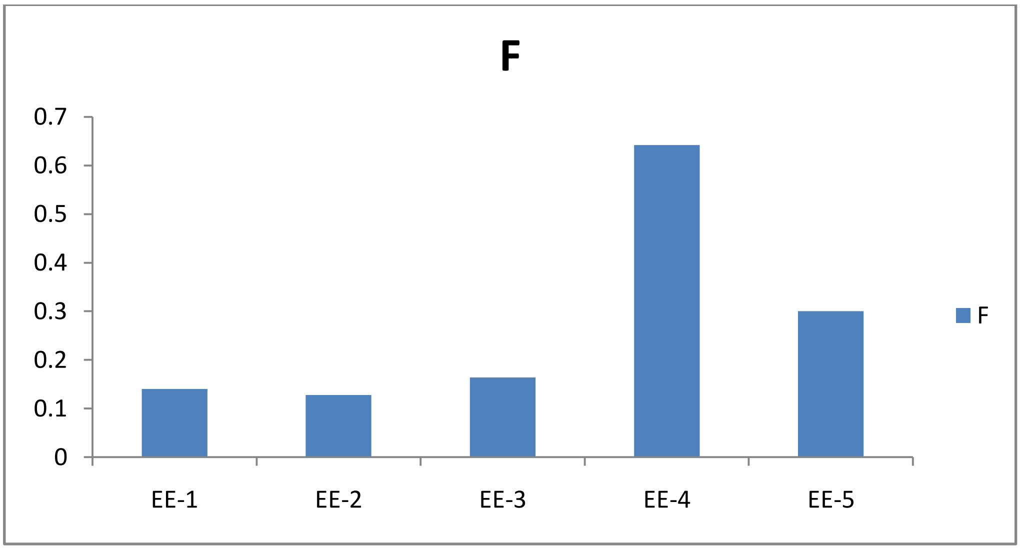

Figure 4.8: Variation of Fluoride in water

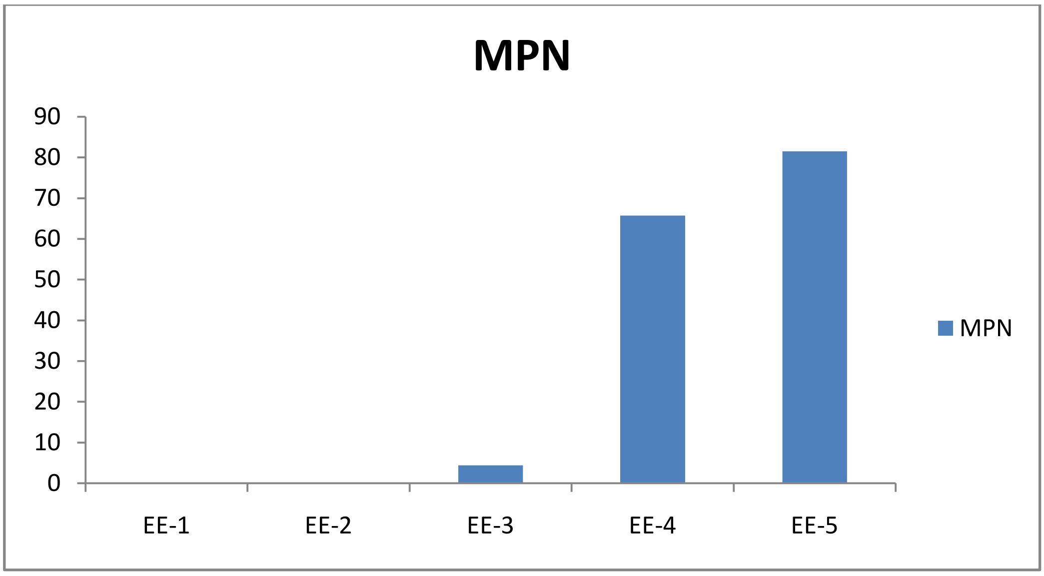

Figure 4.9: Variation of MPN in water

pH was slightly acidic for water at EE-1 and EE-2 and slightly alkaline at EE-4 & EE-5. The alkalinity for water at EE-4 accounted for a high value of 95 mg/l of $CaCO_3$. Large hardness values (305 mg/l) were observed for both surface and ground water at EE-4 and EE-5 respectively. The lower values (28 mg/l) were noticed in all RO treated water at EE-1, EE-2 & EE-3. Clearly TSS & TDS proportion was large for EE-4 & EE-5 where as it was small for EE-1 to EE-3. The high chlorides for water at EE4 and EE-5 (65 mg/l) compared to others was noticeable. Fluoride value (0.3 mg/l) at EE-5 for ground water compared to others was observed. Coliform values at EE-4 & EE-5 (65/100 ml, 80/100 ml) for surface and ground water was alarming observation.

Many of the parameters analysed indicated the drinking water of good quality at EE-1 & EE-2. A small MPN count of 8/100 ml along with chlorides and fluorides of 45 mg/l and 0.164 mg/l occurred at EE-3. The situation was poor at EE-4 & EE-5 for essential health related parameters in water.

4.3 Proposing feasible options for wholesomeness of water

The water quality at EE-1 and EE-2 indicated that most of the parameters are within the limits and is good. A small MPN count of 5-8/100 ml with chloride values 45 mg/l was observed at EE-3. Routine maintenance, timely servicing are essential for better performance of purifiers.

The water quality at EE-4 and EE-5 for surface water and ground water was objectionable. From the health point of view of consumers, the water collected for serving should be representative and be stored in containers which are sufficiently cleaned & covered. The premises of tube well, municipal tap require protection from unwanted entry of drainages. Workers may be trained to adopt clean habits such as not to dip hands, isolation from food handling in case of illness etc. A simple settling followed by chlorination would enhance excess solids removal and destruction of coliform count. A 2 step method of cleaning utensils i.e. detergent cleaning and sanitization be practised at EE-4 and EE-5.

CHAPTER 5

CONCLUSION

Based on the study performed on water quality at eating establishments, the following conclusions are drawn.

- The eating establishments (EE-1 & EE-2) are characterized superior in terms of water quality provided, food service practices, sanitation and appliances etc., EE-3 is of moderate behaviour; EE-4 & EE-5 are of unscientific.
- Drinking water provided is of constant quality at EE-1 and EE-2; is quite variable and more objectionable at EE-4 and EE-5 from salts and coliforms point of view.
- The authorities at EE-1 and EE-2 should maintain the water quality standards, better performance of RO purifiers by routine maintenance, timely servicing for customer satisfaction, feasible options for water treatments viz settling, chlorination are to be looked at EE-4 and EE-5.

Future scope

- Studies on habits of workers, methods of water storage in containers, patterns of service to customer at eating establishments.
- Classification of eating establishments, involving more number, ranking of water quality may be conducted.

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