A STUDY ON PERFORMANCE EVALUATION OF DOMESTIC WATER PURIFIERS

Thesis submitted in partial fulfillment of the requirements for the award of degree of

Master of Technology
in
Environmental Science and Technology

Submitted
By

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DECLARATION

I, the undersigned, hereby declare that the research work presented in the M.Tech project entitled "A Study on Performance Evaluation of Domestic Water Purifiers" has been carried out by me under the supervision and guidance of. Mr. K.S. Babu, Assistant Professor, Department of Biotechnology and Environmental Sciences, 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 thesis entitled; **"A Study on Performance Evaluation of Domestic Water Purifiers"** by **Ms. Ravinder Kaur Saini** in partial fulfillment of the requirements for the award of **Master of Technology** degree in **Environmental Science and Technology** at **Thapar University,** Patiala (Deemed University) is an authentic piece of work carried out by her under my guidance and supervision.

To the best of our knowledge, the matter embodied in this thesis has not been submitted to any other university/institute for award of any degree/diploma.

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ABSTRACT

A study on the performance of domestic water purifier was conducted between Jan-May 2012. Purifiers aquaguard, Green RO, Pureit, and Kent RO, found installed at TU campus and Aquafresh at Anand Nagar were selected for the study. The Raw water available and treated water generated was analysed for physic-chemical analysis. It was observed that raw water at Anand Nagar was more unhygienic compared to that of campus. Green RO and Kent RO showed maximum removal of water contaminants. Performance of purifiers was aggregated as water quality index (WQI).WQI values declined for treated water quality compared to raw water, indicating that the treatment went in purifier.

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1.1 General

Water is a key to societal stability and cultural diversity. The village administration city municipality collects the raw water from a surface, treats it upto a desired degree and supplies to the dwellers with adequate pressure. Conventionally, the introduction of bottled water or "packaged mineral water" introduced a decade ago has changed the tradition of serving and consuming drinking water. This has ushered the use of polymers or plastics as materials for water storage and distribution.

The categories of bottled water in India are Packaged Natural Mineral Water and Packaged Drinking Water. The packaged drinking water in India, which is estimated at Rs.850 crores with over 200 brands floating in the market, most of which have restricted territorial distribution. This is a growing market in India as quality consciousness among the consumers is on the rise. The bottled water market is growing at a rapid rate of around 20%. Multinationals companies such as, Coca-Cola, Pepsi, Nestle and others are trying to grab a significant share of the market in this section. The per capita consumption of bottled water in India is less than half a litre per year, compared to 111 litres in France and 45 litres in the US.

Major Players like Parle Export introduced Bisleri in India 25 years ago. Parle Agro with Bailley, Godrej Foods with its Golden Valley, Coca-Cola with Kinley, PepsiCo with Aquafina, Nestle India with Perrier, Mohan Meakins and SKN Breweries entered the market with Golden Eagle and Penguin mineral water, respectively. Nonetheless, Bisleri and Bailley, both of Parle Origin ,enjoy about 50% market share and has become almost generic with the product.

1.2 Objectives of municipal water treatment

The three basic purposes involved with by municipality water treatment are as follows:-

- To produce water that is safe for human consumption
- To produce water that is appealing to the consumer

- To produce water using facilities which can be constructed and operated at a reasonable cost.

Production of biologically and chemically safe water is the primary goal in the design of water treatment plants. A properly designed plant not only to guarantes safe drinking water, but also facilitates skillful and alert plant operation and attention to the sanitary requirements of the source of supply and the distribution system .Ideally, appealing water is one that is clear and colorless, pleasant to the taste, odorless, and cool. It is none staining, neither corrosive nor scale forming, and reasonably soft. The consumer is principally interested in the quality of water delivered at the tap, not the quality at the treatment plant. Therefore, water utility operations should be such that quality is not impaired during transmission, storage and distribution to the consumer.

The third objective of water treatment is that water treatment may be accomplished using facilities with reasonable capital and operating costs. Various alternatives in plant design should be evaluated for production of cost effective quality water. In general municipal water is adequate in quality, superior in quality and supplied with sufficient pressure to the residents. The scheme of conventional water treatment may be a failure due to multiple location of treatment units in the city, their inefficient operation and maintenance and lack of technical manpower etc.

1.3 Water requirements at special occasions

At the military operation or emergency situation such as epidermics, fair and festivals. Larger quantity of water of higher degree of quality compared to that provided by conventional treatment is required . The administration by utilising multiple sources of water and by installing highly efficient treatment units units meet these needs. Besides, people having their own sources of water withdraw the water and utilise it within their premises after proposing treatment individually at small scale level.

Several manufacturers have introduced water purifiers in the market so that an individual may purchase and get them installed at their home conveniently. Aquaguard from Eureka Forbes, remains the market leader, since long time. Usha Shriram with its, has launched India’s first digital water purifier-the water guard Digital in collaboration with Brita GmbH of Germany. HLL has also forayed into the water business, with its water purifier device called Pure.

Water Purifiers (residential segment) are growing at 22-25% annually. It is a Rs 5 to 6 billion industry, with Aquaguard cornering more than 50% of the market. The rest is divided among Kent RO, Pentair, Ion Exchange and Others.

1.4 Packaged mineral water –the trend

Water treatment scheme consists of aeration, chemical coagulation, flocculation, sedimentation, filtration and disinfection etc. The backwash water and sludge generation from water treatment plants are of environment concern in terms of disposal. Therefore, optimization of chemical dosing and filter runs carries importance to reduce the rejects from the water treatment plants. Also there is a need to study the water treatment plants for their operational status and to explore the best feasible mechanism to ensure proper drinking water production.

Water quality criteria for designated best uses (for drinking water, outdoor bathing, propagation of wildlife & fisheries, irrigation, industrial cooling) have been developed by the Central Pollution Control Board. The limits for criteria pollutants are given in **Table 1.1.**

Table 1.1: Water Quality Criteria for Designated Best Use

S.no.	Designated best use	Class	Criteria
1.	Drinking Water Source without conventional treatment but after disinfection	A	Total Coliform organism MPN / 100 ml shall be 50 or less, pH between 6.5 and 8.5, Dissolved Oxygen 6 mg/l or more BOD 5 days 20°C, 2 mg/l or less
2.	Outdoor bathing (organized)	B	Total Coliform organism MPN / 100 ml shall be 500 or less, pH between 6.5 and 8.5, Dissolved Oxygen 5 mg/l or more BOD 5 days 20°C, 3 mg/l or less

3.	Drinking water source after conventional treatment and disinfection	C	Total Coliform organism MPN / 100 ml shall be 5000 or less ,pH between 6 and 9 ,Dissolved Oxygen 4 mg/l or more Biochemical Oxygen Demand 5 days 20°C, 3 mg/l or less
4.	Propagation of wild life and fisheries	D	pH between 6.5 and 8.5 , Dissolved Oxygen 4 mg/l or more Free ammonia (as N)1.2 mg/l or less
5.	Irrigation, industrial cooling, controlled waste disposal	E	pH between 6.5 and 8.5 , Electrical Conductivity at 25°C micro mhos /cm Max. 2250 ,Sodium absorption ratio max 26 Boron max. 2 mg/l

1.5 Research problem

Having recognised the importance of water purification at the individual level, an attempt is made to make a study on the performance of domestic water purifiers available at different locations of city. Five types of filters included in the study were Aquaguard, Green RO, Pureit , Kent RO and Aquafresh. The study was performed during Jan –May 2012.

The work elements included were:-

- To understand the types of treatment components involved with the water.
- To analyse the quality of raw water treated water produced by the purifiers.
- To aggregate the performance of purifiers with water quality index (WQI) calculations.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

2. General

In the conventional type /large scale level of water treatment provided by the village administration city municipality, raw water is collected from distant source, purified through treatment units sedimentation-coagulation-filtration-disinfection etc., for all practical purposes municipal water is the best and the cheapest . The administration aims the health of citizens the primary.

2.1 Disadvantages of large scale system in tackling domestic water issues

Large scale systems have many disadvantages in many areas of sustainability. Economically, they are too expensive for developing countries like Indonesia, and from the local community perspective these systems can often be disruptive and do not encourage community involvement. Water supply systems at large level involves huge land and investment. Operational and maintenance troubles are commonly associated with them. Lack of technical manpower and skilled supervision aggregate the problems existing already.

Sewerage systems **require large-scale disruption** and in dense Asian cities this would be magnified many times over affecting existing infrastructure such as roads, housing, electricity and telecommunications. One of the main **disadvantages** of large scale wastewater treatment projects is that **they are normally implemented using a top down process rather than building on existing community values and cultural heritage and involving the local community.**

2. 3 Small scale treatment technologies

Small scale treatment technology aims to operate at the local community level and is considered to have the following characteristics:

- Simple operation and maintenance methods;
- Minimises high skill demands;
- Low operating and maintenance cost;

- Uses local resources and materials available
- Easily adjustable to different circumstances at the local level.

The idea of small scale community technology is to bring together the philosophy of technology with existing cultural heritage at the local community level and to implement the technological solution. Effectively Indonesia already has a strong cultural heritage at the local community level known as *Gotong Royong*. The meaning of *Gotong* is 'carrying work together'. The meaning of *Royong* is 'distributing the earnings or income'. Thus *Gotong Royong* is a cultural heritage that means working together for the benefits of the community

The concept can also help encourage and lead people within the community to face and overcome problems together, to share and bear the burden of life together (Pacific Century E-Media 1996). At the military operation, emergency cases such as epidemics and special occasions like fairs and festivals more water is extracted through portable intakes and or treated water of high purity is supplied. The requirement of small scale water treatment is altogether different from that of municipal water requirement. Besides residents also install water purifiers at their houses for obtaining superior quality of treated water to safe guard their health.

2.3.1 Water treatment at individual level

Water Treatments at individual level involves treatment of water focussing on removal of undesirable: Taste, Odour, Hardness and Contamination.

The common water treatment methods used at individual level are listed and discussed below:-

1. Boiling
2. Distillation
3. Reverse Osmosis
4. Water Filters
    a. Sediment Filters
    b. Activated Carbon
        i. GAC
        ii. Solid Block
        iii. Pitcher and Faucet-Mount Filters

5. Bottled Water
6. Ultra Violet Light
7. Ion Exchange
8. Water Softener
9. KDF
10. Ozonation

Most of the methods of water treatment are of Point of Use (POU) devices. **POU methods treat water at the point where is used** - frequently at the kitchen sink. Only the water that is actually used for drinking, cooking, beverage preparation, etc. is treated. This has the advantage of economy - only a few hundred litres of water need to be treated per year instead of many thousands if all of the water entering the home were to be treated. **Most people who use water supplied by a municipal water company about POU treatment**, because it is the water company's responsibility to provide biologically and chemically safe water that has most objectionable taste and odor causing substances removed. Most people using public water do not need to employ Point of Entry treatment devices or the more expensive POU devices like distillation and reverse osmosis.

Point of Entry (POE), or whole house water treatment (where all water entering the home is treated) is indicated when the water has problems that affect all areas of the home. The most common example is water softening ion exchange system that removes calcium and magnesium ions from the water. Other POE water treatment systems are designed to remove iron and manganese, adjust pH levels, add chlorine or other disinfectant, etc. **People using water from a private well, spring, or surface source require POE treatment.**

2.4 Domestic water filter technologies

Several companies are involved in introducing water filters in the market from time to time that are suitable for installation at the domestic areas and for getting treated water of desired degree.

The claims made by the manufacturers and the technical features of the domestic water filters are presented below:-

2.4.1 AQUAGUARD:-The water purification system achieved in the filter is referred to as SENSA. The purifier has

- 7 technologies that cure 17 water problems
- Over 29 years of experience
- Backing of 105 water testing labs worldwide
- Endorsement by the Indian Medical Association
- Technology equipped to purify bore well, mixed, tanker, municipal, stored and tap water
- A strong service network across India
- The trust of 8 million families
- Guaranteed purity in every drop
- Over 1000 service centres across the country

Technical features:

The water purifier is equipped with the purification technologies – RO+ UF+ UV that can purify any kind of water. **Fig 2.1** depicts the detailing of aquaguard water filter.

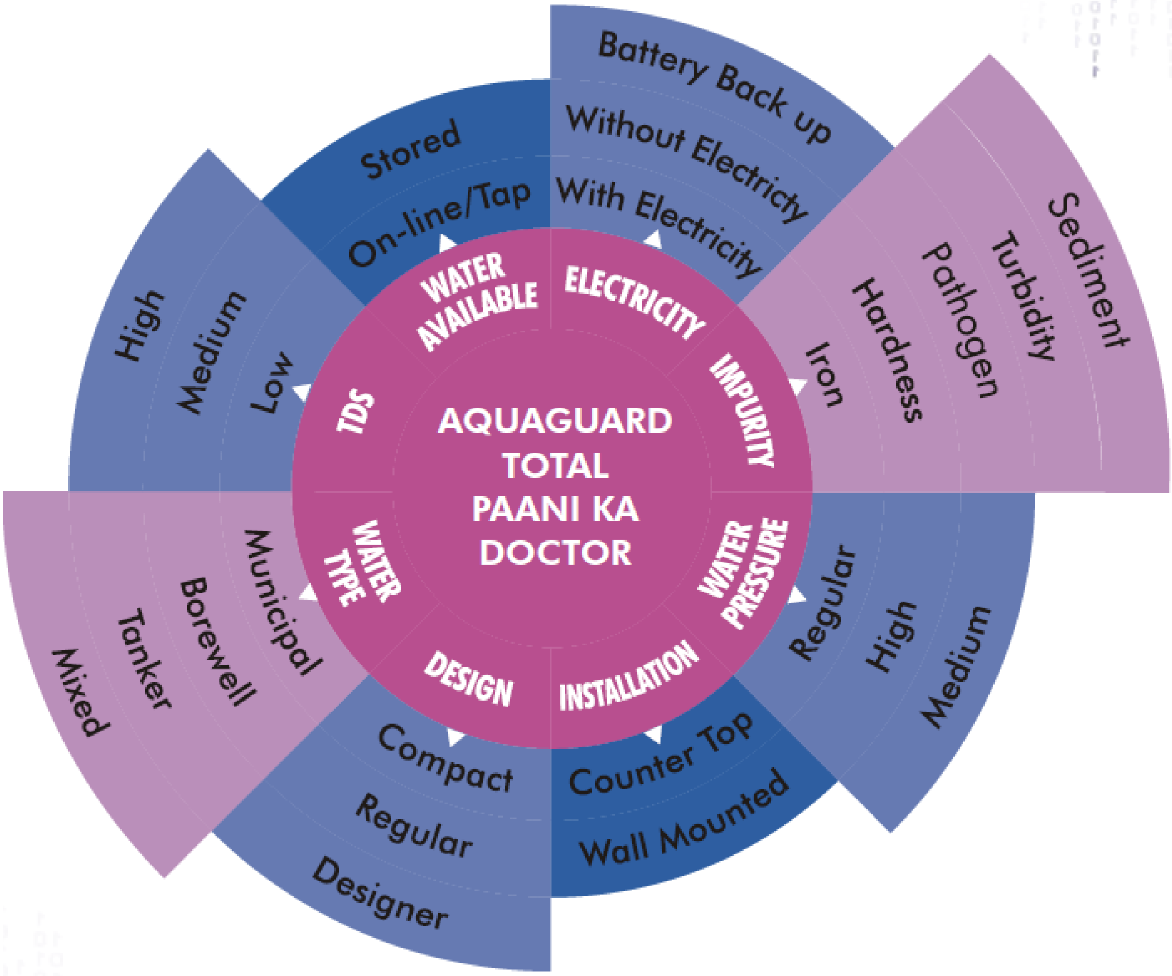

Fig 2.1 Detailing of aquaguard water filter

- SMP+ Technology Ensures that the TDS level in water remains constant, so that ones get water that's sweet + with a healthy balance of natural minerals + 100% pure water.

- **BLUG Technology**

  Senses the quality of water, then chooses the optimum purification technology – RO+ UF+ UV+ to purify the water.

- UF+ **Technology**

  Equipped with revolutionary UF technology, a capillary tube-based technology. That not only guarantees water that's pure, but crystal clear and tasty too.

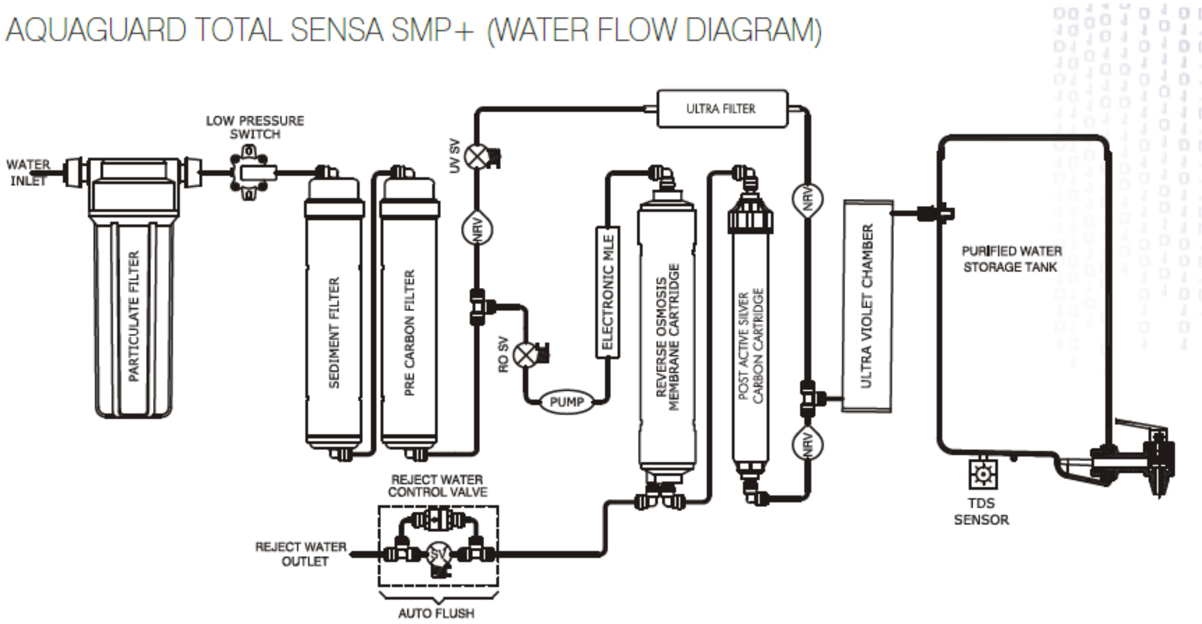

Fig 2.2 Aquaguard Total Sensa Smp + (Water Flow Diagram)

Table 2.1: The multi-stage purification process of aquaguard total sensa filter

STAGE	TREATMENT	MATERIAL	BENEFITS
1	Particulate filter	Polypropylene yarn – wound	Removes large visible impurities
2	Clarity filter	Polypropylene melt-blown	Removes finer suspended particles such as dirt and sand from water
3	Pre-active silver cartridge	Bacterioststic organic remover	Removes excess chlorine and organic impurities it also adsorbs bad taste and odour from the water
4	Electronic membrane life enhancer	Electromagnetic technology	Prevents scaling of dissolved salts like calcium and magnesium, thus enhancing the membrane life and improving water flow

5	Reverse osmosis cartridge	Thin film composite(TFC) reverse osmosis membrane	Reduces TDS, hardness flourides, pesticides and heavy metals like arsenic,lead,and mercury .And removes disease causing micro-organisms likebacteria,virus,protozoa and cysts.
6	UF technology		A capacity tube based technology that not only guarantees drinking water that's pure and safe but crystal clear and tasty too.
7	Post active silver carbon cartridge	Bacteriostatic taste enhancer	Removes residual organic impurities and revives the original taste of water . The carbon polishes the water giving it a sparkling look making it pure and great to taste.
8	UV treatment	UV lamp	Eliminates diseses causing bacteria ,virus,protozoa and cysts.

Table 2.2: Other specifications of aquaguard filter

S.NO.	Parameters	Specifications
1	Dimensions (WxHxD) in mm	344 x 322 x 473
2	Net weight	12.26 kg
3	Tank capacity	9.5 litres
4	Purifying Technology	Reverse Osmosis/UV Purification
5	Filter Cartridges	Particulate Filter Clarity Cartridge

		Pre-Active Silver Carbon Cartridge Electronic Membrane Life Enhancer RO Membrane Post-Active Silver Carbon Cartridge Ultra Filtration Cartridge UV Purification System
6	RO Membrane	TFC Spiral
7	Uv lamp	5000 working hrs
8	Power rating	40 watts
9	Input Water Pressure	0.6 kg/sq cm(min.)<2 kg/sq cm
10	Input voltage	230 V AC/50 Hz
11	Input Water Temperature	Min. 5 C and Max. 45 C

Table 2.3: Recommended input water quality specifications

S.NO.	**PARAMETERS**	**SPECIFICATIONS**
1	TDS	Up to 2000ppm
2	TOTAL HARDNESS	600ppm(max)
3	IRON	0.3 ppm(max)
4	CHLORINE	0.5ppm(max)

2.4.2 Green R.O. water purifier

Eureka Forbes Ltd has launched world’s first green RO water purifier – Aquaguard Total Enhance under its RO water purifier range. The Enhance range comprises of three types of RO water purifiers catering to different Total Dissolved Solids (TDS) levels in water. The Green RO is specially designed for areas where the TDS level is less than 500mg/l, the Enhance RO removes excess TDS between 500-1500mg/l and makes the water pure. The specially designed high-tech membrane caters to the different TDS levels in water. It also reduces hardness from water without compromising water quality and taste.

Enhance Green RO, is considered one of the best RO water purifiers in the industry, as corroborated by users’ comments and reviews .the reasons attributed are :Scaling of dissolved salts like calcium and magnesium is prevented by Electronic Membrane Life Enhancer (EMLE), Flow of crystal clear water is ensured by particulate filter and clarity cartridge Special carbon cartridge is used for removal of residual organic impurities and revival of original taste, elimination of tough new-age contaminants.

The Reverse Osmosis technology deployed in Enhance makes use of high pressure through a thin film composite membrane which rejects about 90% of high salts, chemicals and biological impurities. It also removes all disease-causing micro-organisms and gives pure and sweet tasting water. Aquaguard Green RO is the world's first environmental friendly water purifier which saves 30% water while retaining essential minerals as compared to other RO purifiers.

Salient Features of Green R.O. Water Purifier:-

- US - FD A grade high quality component.
- NASA approved technology.
- Spiral wound TFC high rejection membrane.
- Compact design allows easy installation.
- Quite high pressure booster pump.
- Fits under the kitchen sink.
- Connects to water cooler for automatic operation.

2.4.3 Pureit

This type of water purifiers made by Hindustan Unilever and sold in several countries., pureit is available in six models: Pureit Classic, Pureit Compact, Pureit Classic Autofill, Pureit Intella, Pureit Marvella and Pureit Marvella RO. Pureit was first launched in Chennai in 2004. Pureit claims to meet the E.P.A. germ-kill criteria.

Purification

Pureit consists of four parts that purify the water in four stages: a 'microfiber mesh', a 'compact carbon trap', a 'germkill processor' and a 'polisher' .For the Pureit Marvella model, the microfibre mesh has been rebranded as a 'pleated filter', while the compact carbon trap has been rebranded as an 'activated carbon filter'. The microfibre mesh functions as a sieve, filtering out visible dirt. The carbon trap removes parasites and pesticides. The processor is a tablet consisting of chlorine. This stage removes bacteria and viruses. The polisher improves taste and clarity of water and removes the residual form of chlorine from the water. These four parts are collectively branded the germkill kit or the battery.

This battery needs continual replacing, as indicated by a germkill battery indicator visible on the front of the device. Pureit also features an 'auto switch off' mechanism whereby the filter prevents the flow of water following the consumption of the germkill kit. The germkill kit is designed to work at 25° C in moderately humid conditions. The germkill kit has an expiry date of three years from the date of packaging.

2.4.4 Kent health care

Computer controlled kent technology combines best of both RO and UV , while eliminating the limitations of a single technology.

- **RO**- Removes even dissolved impurities like arsenic, rust, pestisides, fluorides etc. besides removing bacteria and viruses.
- **UF**- Removes bacteria and Cysts.
- **UV**-For double purification, totally kills remaining bacteria and viruses.
- **TDS CONTROLLER**:-Maintains essential natural minerals in the purified water by adjustment of TDS.

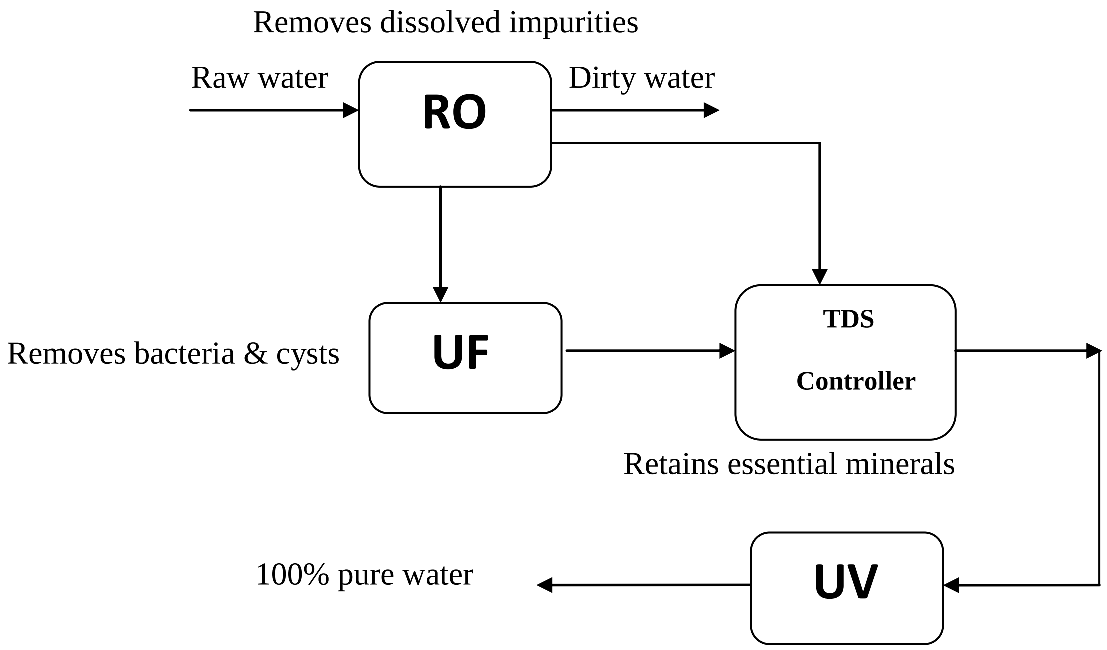

Fig 2.3: Treatment process of kent filter .

The steps involved with kent while generating treated water with raw water are given below in Fig 2.4 .

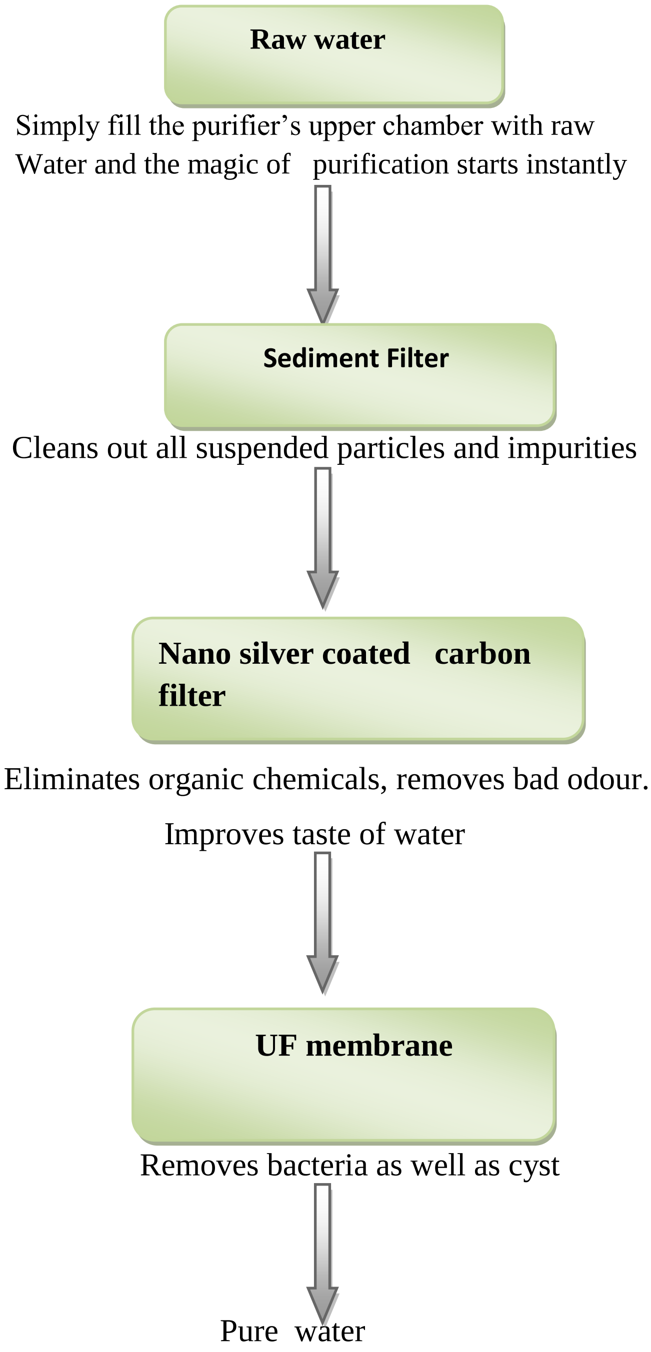

Fig 2.4 Schematic diagram of treated water generation in kent filter.

2.4.5 Aquafresh

Aqua Fresh RO System is an ISO 9001:2008 certified brand. This year Aqua Fresh RO System Delhi branch had completed 17 years since its introduction in the year 1994 .Aqua Fresh RO water Purifier gives you drinking water at the touch of a button. water Purifier removes the unhealthy sodium and as well as other dissolved solids, nitrates and heavy metals. It will even remove chemicals, carcinogens and human waste from the sewage treatment plant process or septic systems.

Aqua Fresh RO water Purifier comes in an easy to install enclosed cabinet and features built in booster pump, quick change filters numbered for easy identification, designer faucet, online storage tank, 50 gallon per day membrane, quick connect fittings and color coded tubing to make the installation simple .

Water Treatment mechanism involved:

- **Ultraviolet:**

  Aquafresh has a range of Sterilight ultraviolet disinfection systems for residential, commercial and municipal applications. Sterilight systems solves the problem of bacterial contamination that can be present in all water supplies, especially rural areas or areas that are not treated by municipal water systems. Sterilight systems can be used as a point-of-entry (whole house) disinfection system for the water supply for an entire home .The low pressure germicidal lamps provide an economical way of treating water requiring a 99.99% destruction of bacteria, virus, and protozoan cysts (Giardia and Cryptosporidium) at the rated flow.

- **Whole House Filtration:**

  These systems are capable of higher flow rates than point-of-use systems. They are the ideal choice for homes affected by heavy sediment problems. And prevent damage to water heaters and dishes through filtration of contaminants. Whole house water filtration can also include carbon filtration to reduce chlorine and other contaminants that create odour and affect taste of water. These systems are installed before the water line enters the house.

- **High Flow Reverse Osmosis:**

  High flow reverses osmosis systems produce from 150 litres to 75,000 litres of pure water per day for further use. Aquafresh have the support and technical backup of CUNO, a 3M Company, and can design, supply and commission the best.Reverse osmosis systems include pre-treatment and storage packages as required.

- **Water Softeners:**

  The water softners reduce the hardness of water thus saving up to 70% on detergent and washing powder costs. No scaly kettles, longer life for plumbing and fittings and enjoying luxurious bathing are observed by users.

- **Automatic Backwash Filter:**

  A range of Automatic Backwashing Filters are available for taste and odour removal, de-chlorination, turbidity reduction, and hydrogen sulphide removal. The systems include fully automatic backwash control, by-pass valve, easy media replenishment without disassembly of unit and seamless fiber glass tank.

- **Iron Removal Systems:**

  High iron levels in water are indicated by red brown staining of plumbing and laundry fixtures and a cloudy appearance and metallic taste to beverages. The an iron removal system in your home will give brighter, whiter clothes, no more staining of clothes and better tasting water.

- **Acid Neutralisers:**

  Typical symptoms of acid water are blue/green staining on plumbing fixtures such as taps and shower roses. The blue/green stains are an indication that acidic water is corroding copper pipes and perhaps creating a health risk. A neutralising filter is the economical solution to this problem.

2.5 Drinking Water Quality Index (WQI)

The water has beneficial utilities such as drinking, industrial, agriculture etc., quality of water required depends on the purpose of its use.

Table 2.4: shows the specifications of water in Indian conditions for drinking.

S.no.	Parameter	Requirement Desirable limit	Remarks
1	Colour	5	May be extended upto 50 if toxic substances are suspected
2	Turbidity	10	May be relaxed up to 9.2 in the absence of alternate
3	pH	6.5 to 8.5	May be relaxed up to 9.2 in the absence
4	Total hardness	300	May be extended up to 600
5	Calcium as ca	75	May be extended up to 200
6	Magnesium as Mg	30	May be extended up to 100
7	Copper as cu	0.05	May be relaxed up to 1.5
8	Iron	0.3	May be extended up to 1
9	Manganese	0.1	May be extended up to 0.5

10	Chlorides	250	May be extended up to 1000
11	Sulphates	150	May be extended up to 400
12	Nitrates	45	No relaxation
13	Fluorides	0.6 to 1.2	If the limit is below 0.6 water should be rejected max limit is extended to 1.5
14	Phenols	0.0001	May be relaxed up to 0.002
15	Mercury	0.001	No relaxation
16	Cadmium	0.01	No relaxation
17	Selenium	0.01	No relaxation
18	Arsenic	0.05	No relaxation
19	Cyanide	0.05	No relaxation
20	Lead	0.1	No relaxation
21	Zinc	5	May be extended up to 10
22	Anionic detergents(MBAS)	0.2	May be relaxed up to 1
23	Chromium as cr^{+6}	0.05	No relaxation

24	Polynuclear aromatic hydrocarbons	------	-------
25	Mineral oil	0.01	May be relaxed up to 0.03
26	Residual free chlorine	0.2	Applicable only when water is chlorinated
27	Pesticides	Absent	----
28	Radio active	------	-----

A water quality index provides a single number that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. The use of an index to "grade" water quality is a controversial issue among water quality scientists. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. The index presented is not specifically aimed at human health or aquatic life regulations. However, a water index based on some very important parameters can provide a simple indicator of water quality.

The steps involved in calculating WQI are:-

Select the quality parameters based on which WQI is to be arrived at

1) Define the importance (weightage) for each parameter (opinion of the expert panel is considered).
2) Measure the values for the selected parameters (done by standard procedures in the laboratory).

3) Convert the all measured values into a common scale known as environmental utility scale (EUS).
4) WQI is obtained by adding all the EUS values.

WQI Rankings

• Excellent - WQI Value 0-25: Water quality is protected with a slight presence of impairment; conditions are close to pristine levels.

• Good - WQI Value 26-50: Water quality is protected with only a minor degree of impairment; conditions rarely depart from desirable levels.

• Poor- WQI Value 51-75: Water quality is almost impaired; conditions often depart from desirable levels.

• Very poor - WQI Value 76-100: Water quality is always impaired; conditions usually depart from desirable levels.

• Unsuitable - WQI Value: Above 100.

The Drinking WQI is not an absolute indicator of the overall safety of the water delivered to the consumers tap. It is one factor that a consumer may choose to consider in evaluating drinking water quality. A community's water may meet the standards used to determine the Index, but may still not be safe to drink from time to time due to bacteriological factors, lack of minimum treatment, infrastructure deficiencies, treatment or disinfection system upsets, or other unexpected occurrences etc.

2.6 Scientific work quoted

Luby et al., (1993) studied the effectiveness of Home Drinking Water Purification Efforts in Karachi, Pakistan. In 293 consenting households, structured observations were performed and drinking water was analyzed for the presence of coliforms, using the multiple tube fermentation technique. Results were ,although 193 of the 293 households (66%) reported using some method to purify their drinking water, including 169 (58%) who boiled their water, only 48 (16%) of the drinking water samples were free of coliforms. Although the combination of boiling and filtering was the most effective method of purification, only 38% of samples that had been boiled and filtered were free of coliforms.

Hodi, (1995) worked on removal of pollutant from drinking water by combined ionexchange and adsorption methods. Na-clinoptilolite was applied for selective removal of ammonium ions. The results showed that the removal of ammonium and arsenic ions as well as humic acids was selective and was not affected by other components of the raw water.

Abbaszadegan, (1996) worked on the disinfection efficiency of a POU water treatment system against bacterial, viral and protozoan waterborne pathogens. The (POU) water treatment system , comprised of a pressed activated carbon block filter followed by an (UV) light reactor, was evaluated for microbial disinfection efficacy. The system was challenged against bacterial, viral and protozoan waterborne pathogens For each organism tested, microbial challenges were conducted over the course of the test period at 0, 50, 100 and 150% of the manufacturer's rated water treatment capacity. The system was found to effectively remove and/or inactivate greater than 99.9999% of the bacterial pathogens, greater than 99.99% of the viruses and greater than 99.9% of the protozoan cysts and oocysts. These findings suggested that a properly designed and operated POU would be a practical approach to removing microbiological waterborne pathogens from drinking water.

Jacangelo et al., (1997) studied the role of membrane technology in drinking water treatment in United States. With the increase in water quality regulations and decrease in available fresh water supplies in the US, pressure driven membrane processes are playing an increasingly important role in drinking water treatment. They are being employed to remove a wide range of contaminants, and depending on their use, can be operated with minimal or no chemical pre treatment that forms deleterious by-products. The major uses of membrane processes include desalting, disinfection by-product control, disinfection, clarification and removal of synthetic and inorganic chemicals.

Ma et al., (1998) studied the application of membrane technology for drinking water. In order to provide high-quality drinking water to the residents, Daqing City started the High-Quality Water Supply Project in 1994. In the first phase, seven polishing water treatment systems consisting of preozonation, microfiltration, activated carbon adsorption, ultrafiltration or reverse osmosis and postozonation were installed in various residential districts. The existing low-quality tap water was used as feed water, and the treated water was distributed to the customers through an independent network or with bottles for drinking and cooking purposes. The total treatment capacity of the seven systems was 620m3/d. The performance of the systems mets the design requirements, and the treated water quality mets the European Union Drinking Water Standard. Economically, both capital investment and operating costs were within the initial budgets and at rational levels.

Saleh et al., (1998) surveyed trace elements in household and bottled drinking water samples collected in Riyadh, Saudi Arabia. Total dissolved beryllium , cadmium , chromium ,copper , iron , magnesium , manganese , mercury , nickel , selenium , strontium , vanadium and zinc were measured in the drinking water of 101 household and 21 samples of retail bottled waters to ascertain the quality for human consumption. The Inductively Coupled Plasma Spectrometer ICP. was used for analysis. First-draw Fe, Mn, Ni and Zn concentrations decreased significantly after 10 minutes of flushing in the morning.

Almeida, et al., *(1999)* made an attempt for accurate measurement of flow and quality determinands for single or small numbers of dwellings. The proposed methodology could be used to derive dry weather flow inputs to water quality models, and to assess the impact of changes in local water use and treatment .

Leeuwen, (2000) mentioned that although, microbiological quality of drinking water has been the main concern, but over the last decades the attention of the general public on the importance of chemical quality and the threat of chemical pollutants have increased with the increase of our knowledge on the hazards of chemical substances. Broadly he divided contaminants into two categories: contaminants originating from surface and groundwater, and contaminants used or formed during the treatment and distribution of drinking water. Contaminants in surface and groundwater can range from natural substances such as arsenic and manganese leaching from soil, to contaminants introduced by human activities, such as runoff€ from agricultural activities, controlled discharge from sewage treatment works and industrial plants, and uncontrolled leakage from land sites and from chemical accidents. He stressed that toxicologists should provide risk assessments for chemical pollutants and derive guidelines for drinking water quality below which no significant health risk is encountered.

Rompre et al., (2001) enumerated and detected approaches for coliforms in drinking water. The aim of their study was to examine methodsa currently in use or which can be proposed for the monitoring of coliforms in drinking water. Approved traditional methods for coliform detection include the multiple-tube fermentation technique and the membrane filter technique using different specific media and incubation conditions. These methods have limitations, however, such as duration of incubation, antagonistic organism interference, lack of specificity and poor detection of slow growing or viable microorganisms. The detection of coliforms based on specific enzymatic activity has improved the sensitivity of these methods. Three molecular-based methods were evaluated here: the immunological, polymerase chain reaction and in-situ hybridization techniques.

Nicolaisen, (2002) worked on spiral wound Membrane technology as a means of producing various qualities of water from surface water, well water, brackish water and seawater. Membrane technology offered the possibility of managing the total water resources holistically in a region. The spiral wound membrane element configuration is the most widely used due to its high packing density and relatively low price. Spiral wound elements span the four commonly defined membrane technologies, which are microfiltration (0.01-O microns), ultrafiltration (500- 100,000 Da), nano filtration (100-500 Da), and reverse osmosis (up to 100 Da).

Meunier et al., (2006) studied on implications of sequential use of UV and ozone for drinking water quality. The formation of bromate levels exceeding the drinking water standard of 10 µg L-1 imposed the reduction of ozone doses used in the treatment of drinking water and illustrated the procedure of evaluating the use of reduced ozone doses while implementing an additional UV disinfection step for an actual drinking water treatment plant. Ozonation was performed at low ozone doses in bench-scale experiments with a pretreated river water from the Paris area (France). Based on the measured transient ozone and OH radical concentrations, the oxidation of micropollutants was calculated. Overall, the combination of ozonation at reduced doses and UV treatment lead to an improved water quality with regard to disinfection, oxidation of micro pollutants and minimization of bromate.

Bordalo and Joana , (2007) conducted a pilot study during the wet season on Bolama Island (West Africa). Twenty-eight shallow wells, were sampled for microbiological, physical and chemical water quality characteristics. A ten-parameter (WQI) adapted to tropical conditions was applied to compare the different wells. About 79% of the wells showed moderate to heavy fecal contamination. From the surveyed parameters, it was found that chemical contamination was less important, although all samples were acidic, with the pH averaging 5.1. The WQI was 4374% (0%—worst; 100%—best quality), showing that the water from the majority of wells was polluted but should be suitable for domestic use after appropriate treatment. At the onset of the wet season, diarrhea represented 11.5% of all medical cases, 92.5% of which were children aged <15 years. They also suggested inexpensive steps to reduce the fecal contamination and 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 biological, chemical and physical drinking water quality from shallow wells. Chemical analyses results 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. In the wet season 50% of the samples had pH values below 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 centralised 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 (including cadmium, copper, lead, chromium and nickel), anions and cations such as fluoride, bromide, nitrates, nitrites, ammonium, sulphates and phosphates, as well as dissolved organic carbon. The parametric values set in accordance with the Directive 98/83/EC were exceeded in the cases of lead (in 2.7% of the samples analysed), chloride (2.4%) and nickel (2.1%). Ammonium, sodium, fluoride, sulphates, nitrates and conductivity were lower than the upper limits by 2% of the total number of samples analysed. The majority of problems were identified in the Cyclades islands due to scarcity of water resources.

Varbanets et al., (2008) studied the decentralized systems for potable water and the potential of membrane technology . Most water-quality problems were due to hygiene factors and pathogens. A range of decentralized systems including thermal and/or UV methods, physical removal and chemical treatment were available .Important boundary conditions for decentralized systems included low costs, ease of use, sustainability, low maintenance and independence of energy sources.

Audenaert et al., (2009) worked on full-scale modelling of an ozone reactor for drinking water treatment. In order to describe the ozonation process, a model including key processes such as ozone decomposition, organic carbon removal, disinfection and bromate formation was developed. Kinetics were implemented in WEST® and simulation results were compared to real data. The predicting performance was verified with a goodness-of-fit test and key parameters were determined through a local sensitivity analysis.

Arnal et al., (2009) worked on Ultrafiltration as an alternative membrane technology to obtain safe drinking water from surface water. Ultrafilterartion represents an effective alternative to obtain safe drinking water, due to its ability to remove microbiological contamination from surface water. AQUAPOT international project, developed was a fully autonomous characterized by its modularity, low-cost and simple maintenance.

Agrawal and Bhalwar , (2009) did study on low cost Household Water Purification and have shown that improving the microbiological quality of household water by point-of-use treatment reduced diarrhoea and other waterborne diseases. The most promising and accessible technologies for household water treatment are filtration with ceramic filters, chlorination with storage in an improvised vessel, solar disinfection in clear bottles by the combined action of UV radiation and heat, thermal disinfection (pasteurization) in opaque vessels with sunlight from solar cookers or reflectors and combination systems employing chemical coagulation-flocculation, sedimentation, filtration and chlorination. In particular those treatments that provide no residual disinfectant solar treatment, UV a multi barrier approach was suggested during treatment.

Srinivasan, et al., *(2009*) worked on treatment of perchlorate in drinking water. Because of its extremely low concentrations and strong resistance to most treatment technologies, perchlorate become one of the biggest challenges currently being faced by the drinking water industry. There has not been any holistic approach performed in removing perchlorate from drinking water. The sources of perchlorate along with the degree of contamination are discussed.

Samantray et al., (2009) attempted to assess the water quality of Mahanadi and its distributary rivers and streams, such as Atharabanki river and Taldanda Canal in three different seasons namely summer, pre monsoon and winter. Four parameters namely pH, Dissolved Oxygen, Biochemical Oxygen Demand and Fecal Coliform were considered to compute Water Quality Index based on National Science Foundation studies.Their findings indicated the deterioration of water quality in the rivers due to industrialisation and human activities.

Greenlee et al., (2009) made an attempt on Reverse osmosis membrane technology that has been developed on desalination plants worldwide. Both brackish water and 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.

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 regions by also considering several other factors. Result of this study showed that increase of fluoride level above 1.33 mg/l in drinking water increased the community fluorosis index value more than 0.6, (an optimum index value above which fluorosis is considered to be a public health problem). Regression plot between water fluoride and bone fluoride levels indicated that, every increase of 0.5 mg/l unit of water fluoride level increases the bone fluoride level of 52 mg/kg unit within 2 to 3 years. Furthermore, the consumption of drinking water containing more than 0.65 mg/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 .

Parmar and parmar, (2010) developed (WQI), using six water quality parameters (DO), (BOD), (MPN), Turbidity, (TDS) and pH measured at five different stations along the river basin from November 2006 to November 2007 . Rating curves were drawn based on the tolerance limits of inland waters and health point of view. Five point rating scale was used to classify water quality in each of the study areas. It was found that the water quality of Subernarekha varied from Excellent to Marginal range .It was observed that the impact of human activity was severe on most of the parameters.

Main cause of deterioration in water quality was due to the lack of proper sanitation, unprotected river sites ,high anthropogenic activities and direct discharge of industrial effluent.

Ramesh et al., (2010) followed an innovative approach for Drinking Water Quality Index—for water from Southern Tamil Nadu. The aim of the present study was to exhaust the limitations of conventional reputed Water Quality Index methodologies through the proposed reliable Drinking Water Quality Indexing system. Modifications were carried out in the methodology of the DWQI development which were parameter categorization, development of sub-index with regression statistics and aggregation function with Min–Max operator. Twenty-two water quality parameters were selected for quality evaluation.

Volker et al., (2010) made an attempt to study Drinking water quality in household supply infrastructure. Microbial contamination of drinking water in public buildings was highlighted. Legionella sp. and Pseudomonas sp. were reported to pose a direct health risk to immune suppressed users. Additionally, for some chemical parameters, such as nickel, iron and lead, a potential risk for the health of consumers was detected. Further data analysis may reveal whether this contamination is related to stagnation where there is only sporadic use or whether other factors are involved in the process of microbial growth in installation systems.

Mwabi et al., (2011) studied the Household water treatment systems in production of safe drinking water by the low-income communities of Southern Africa. He did extensive survey to regroup various household treatment devices that are suitable for the treatment of water on basis. The survey has resulted in the selection of four household treatment devices: the bio sand filter, bucket filter, ceramic candle filter and the silver-impregnated porous pot filter. The performance of the four filters was evaluated in terms of flow rate, physicochemical contaminant (turbidity, fluorides, phosphates, chlorophyll a, magnesium, calcium and nitrates) and microbial contaminant (Escherichia coli, Vibrio cholerae, Salmonella typhimurium, Shigella dysenteriae) removals. A higher performance in chemical contaminant removal was noted with the bucket filter. For pathogenic bacteria, the mean percentage removals ranged between 97% and 100%.

Singla et al., (2011) evaluated the water quality of different localities of Raipur block eastern Doon vallies in different months of the year.WQI for drinking water of eastern Doon valley has been calculated with the help of estimated value of different physic-chemical parameters such as pH, turbidity, conductivity, alkalinity, hardness, DO, BOD, COD, Ca^{+2}, Mg^{+2} and heavy metals like Fe^{+2},Mn^{+2} and WHO drinking water quality standards.

Shan et al., (2011) found some substances gradually accumulating in our drinking water source—the surface water, and finally threatening drinking water safety when their contents reached a certain amount. To represent those potential threats on water safety, WQI was chosen. To take proper countermeasures was built a water quality model simulating change trend of the water source quality.

Jardim et al., (2011) followed an integrated approach to evaluate emerging contaminants in drinking water at Brazil by using both chemical and biological analyses. Contaminants such as Estrone, bisphenol were determined in the samples by liquid chromatography–tandem mass spectrometry. A yeast assay using a *Saccharomyces cerevisiae* bioluminescent bio reporter was used to evaluate the estrogenic activity of the water samples.

The information quoted above indicates that treatment of water has been attempted from laboratory to pilot plant level. Not many scientific reports are available or the types of domestic water purification systems quality of treated water available from them and their operational and maintenance details etc.

CHAPTER 3

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This chapter discusses the materials used and the methodologies adopted during the study.

- Chemicals-chemicals used were of analytical grade with sufficient purity.
- Instruments-All instruments with accuracy procured from authorized dealers were employed for measurement of characteristics of samples.
- Calibration curve- They were prepared from stock solutions, before estimating the unknown parameters (nitrate, phosphate etc.) and were used throughout the study.

3.1 Collection of samples

Selection of sources:- A preliminary survey was made at Thapar university campus and Anand Nagar , Patiala and different types of water purifiers used by residents were observed. By keeping the accessibility convenience operation and maintenance condition of the water purifiers four residential sources raw water samples and treated water obtained from the purifiers were collected at fortnight intervals during the study period from Jan –May 2012 at Thapar campus and one at Anand Nagar.

Table 3.1 Sources and types of water purifiers installed

S.NO.	SOURCE	NAME OF PURIFIER INSTALLED
1	Residence -1 at TU	Aquaguard
2	Residence -2 at TU	Green R.O.
3	Residence -3 at TU	Pureit
4	Residence -4 at TU	Kent R.O.
5	Residence -5 at Anand nagar	Aquafresh

Containers- Raw water samples and treated water samples were collected from outlet of kitchen tap and from outlet of water purifier respectively in acid rinsed polyethylene containers (Jerry canes) of 2l capacity. For coliform detection samples were collected in sterilized BOD bottles.

Sample collection and preservation- Samples of raw water and treated water collected were representative and were transported to laboratory and preserved at 4 ^{0}C refrigeration prior to the analysis. Analysis was completed within 72hrs of collection .

3.2 Characterization of samples

Samples of raw water and treated waters collected from various sources and purifiers were analyzed for

1. Physical
2. Chemical
3. Biological properties

by using Standard Methods for Examination of Water and Wastewater, (APHA,1992).

3.2.1 Physical analysis

pH

The pH of samples was measured by electronic meter, after calibrating the pH meter with buffer solution of pH 4.0 ,7.0 & 9.2.

Turbidity

Turbidity of samples was measured by Nephelometer, using optical properties of light.

Total solids

Total solids were determined using gravimetric technique .A well mixed sample was evaporated in weighed beaker and dried to constant weight in an oven at 103 to 105^{0}C . The increase in weight over that of empty beaker represents the total solids.

Dissolved solids

Dissolved solids were determined in water after filtration through whatman filter 44.

Suspended solids

Suspended solids (SS) from sample was calculated as SS= Total solids- Dissolved solids.

Total Hardness

EDTA titration method with the presence of EBT indicator was adopted.

Permanent Hardness

Above method was performed with raw water.

Temporary Hardness

It is the difference between total and permanent hardness.

3.2.2 Chemical analysis

Chloride

Chloride was determined using Argentometric volumetric titration method. Potassium chromate indicates the end point of silver nitrate titration of chloride. silver chloride was precipitated quantitatively before red silver chromate was formed.

Nitrate

Cadmium reduction method was used for quantitative analysis of nitrate. NO_3^- is reduced almost quantitatively to nitrite (NO^-_2) in the presence of cadmium (Cd). This method uses commercially available Cd granules treated with copper sulphate and packed in a glass column.

Fluoride

Fluoride estimation was done by coloriometric method .This method is based on the fading of zirconium-SPANDS 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

.

Phosphate

Stannous chloride method (colorimetric method) was adopted in which Molybdophosphoric acid was formed and reduced by stannous chloride to intensely colored molybdenum blue.

Dissolved oxygen (DO)

DO was determined by winklers method . Method depends upon the fact that oxygen oxidizes Mn^{2+} to higher state of valancy under alkaline condition and manganese in higher states of valence is capable of oxidizing I^- to I_2 under acid conditions.

Thus, the amount of I_2 released is equivalent to dissolved oxygen originally present. The iodine is measured with standard sodium thiosulfate and interpreted in terms of dissolved oxygen.

3.2.3 Biological analysis

Total coliform

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

3.3 Water quality index

10 quality parameters of water (raw and treated by purifiers) i.e. pH, turbidity, hardness, chloride, flouride, TDS, TSS, phosphate, nitrate, DO, were used for determining WQI by using the methods proposed by Horton(1965) and further modified by Tiwari and Mishra,(1985) .

In the first step, all the physico-chemical parameters have been assigned a weight (w_n) according to their relative importance in the overall quality of water. The expertise of a panel was utilised for this purpose. The maximum weight of 5 value has been given to a major important parameters and 1 value is given to that parameter which is less important.

In the second step, the relative weight (W_n) is calculated by the following equation:

$W_n = w_n / \sum_{n=1}^{10} w$

Where W_n is relative weight, w_n is weight of each parameters and n is no. of parameters.

In the third step, a quality rating scale (q_n) is calculated

$q_n = V_n/V_s$

where V_n is actual amount of n^{th} parameter and V_s is standard value of each parameter.

In fourth step,WQI is calculated as:

$WQI=\sum_{n=1}^{10} Wn.\,qn \times 100$

Table 3.2: WQI Rating

WQI Value	Meaning
0 – 25	Excellent
26 – 50	Good
51- 75	Poor
75 – 100	Very poor
>100	Unsuitable

CHAPTER 4

RESULTS AND DISCUSSIONS

CHAPTER 4

RESULTS & DISCUSSION

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

4.1 Sources of raw water and treated water

The raw water was collected from the outlet of the kitchen tap and the treated water was obtained from the outlet of purifiers i.e. Aquaguard, Green R.O., Pureit, Kent R.O. (located at residence 1 to 4, TU campus) and aquafresh (located at residence -5 , Anand Nagar, patiala).

4.2 Treatment units associated with the water purifiers

The total purification of water achieved in aquaguard purifier referred to as SENSA has units RO+UF+UV. It is claimed to produce tasty water with a balance of minerals and devoid of infectious microorganisms. Its application to purify bore well, mixed, tanker, municipal stored and tap water indicates the robustness of purifier. The high tech membrane catering to treat water of varying TDS makes the Green R.O. purifier the superior as per the claim of Euroka Forbes Ltd. Use of carbon cartridge in eliminating the residual organics seems to be novel approach.

The four stages such as microfiber mesh, carbon trap, germ kill processor and polisher serving in producing tasty and germfree water make the pureit the most common in domestic applications. The auto switch off mechanism and the battery indicator are the special features involved. The sequence of units RO+UF+TDS controller +UV of a kent R.O. purifier is advantageous in generating completely safe water. Its working without electricity and use of chemicals provide a flexible operation.

The effectiveness of Aquafresh purifier , an ISO 9001:2008 certified brand in the removal of salts ,nitrates and heavy metals is worth to mention. Easy installation features of the purifier add to the convenience of residents. One of the requirements of treatment plants is to include as many stages as possible and produce the most superior quality of treated water. The same has been observed in the construction of purifiers discussed above.

The holistic approach of Srinvasam et al., (2009) in removing perchlorate from drinking water and the integrated approach followed in evaluating emerging contaminants by Jardin et al., (2011) support the innovative ideas of design of the water purifier by the manufacturers.

4.3 Characterization of samples

Water samples collected were analysed for physic-chemical and biological properties and the results are represented in table 4.1-4.6. The overall values of the same properties prevailed during the study period are included in table 4.7. WHO standards for drinking water is shown in table 4.8. pH represents the intensity of acidity of water. For drinking water pH should not be either acidic or alkaline. Acidity makes the water sour and alkalinity the bitter. pH is essentially considered in corrosion control, disinfection, softening of water etc.

Hardness the resistance to produce sufficient lather when water reacts with soap. Although hardness is not serious in municipal water, the use of hardwater in industries brings boiler scale, corrosion, priming and foaming etc. Total hardness is contributed by CO_3^{-2}, HCO_3^- and Cl^-, SO_4^{-2} of Ca^{+2} and Mg^{+2}. By boiling HCO_3^- is precipitated out and the temporary is reduced. Dissolved solids in water results from the solvent action of water. Mineral, springs, carbonate deposits, sea water intrusion and chemicals added during treatment contribute to dissolved contribution. They add salinity in the water and interfere with quality of industrial products made. Chlorides are a portion of dissolved salts expected commonly in water.

Suspended solids are resulting from erosive action of water flowing over land surface. They get deposited in river beds and create flooding. The ugly scene on the river affects the best usage of water. Turbidity is the resistance to the passage of light and it increases the O&M cost of filter, reduces the effectiveness of chlorination. Suspension of water quality with presence of turbidity is reported by the consumers.

Nitrate and phosphate enter the water through agriculture runoff, domestic and industrial wastes. Their accumulation in water body deteriorates the water quality.

Dissolved oxygen enters water through atmospheric diffusion and its level should be adequate to support the growth of a aquatic animals like fish. excessive DO is reported to cause corrosion problems.Water is enriched with flouride due to its contact with geological rocks. F^- is desirable by humans for making strong teeth and bones. Excess concentration of the same leads to the dental and other health problems.

Presence of indicators (E-Coli) is calculated with most probable number (MPN) from drinking water. MPN determines the involvement of disease causing organism in impairing the human health.

4.3.1 Raw water analysis

The raw water at the first four purifiers located at TU campus has pH around 7.5. A total hardness of 200mg/l with its temporary hardness of 50mg/l results a permanent hardness of nearly 150mg/l($CaCO_3$).

Total dissolved solids are comparatively smaller than total suspended solids. Chlorides value of nearly 150mg/l matches with lesser proportion of TDS. A high turbidity of around 20-30NTU accounts for larger TSS values. A high DO content 6-8mg/l is observed indicating its health potential. Nitrate content of 20-25mg/l and P content of 0.1-0.4mg/l show its non risky behaviour. Lack of F and MPN adds to the safe quality of water (Table 4.7).

The water at TU campus has ground water source. Here water is pumped to a overhead reservoir and directly supplied to the residences, ground water generally has more temporary hardness, more dissolved solids. Its non exposure to atmosphere requires less DO. As ground water is filtered water through soil layers its microbial content should be less.

Few parameters of the analysed results are as against the standard quality of ground water.

The raw water at the fifth purifier (aquafresh) from Anand Nagar, Patiala has a source of municipal water. Its pH value is 7.3. Total hardness of 185mg/l ($CaCO_3$) and chloride of 20 mg/l has a certain trend. Large TSS value of 800mg/l with high turbidity of 25mg/l indicates the erosive origin of the source. Detection of MPN value upto 40no./100ml indicates its inferior quality.(Table 4.7).Surface water originates through runoff. It has more suspended solids with a domination of permanent hardness .It is characterized of large DO content ,and a large possibility for fecal coliforms.

My findings coincide with the standard quality of surface water. variations in raw water quality occur due to seasonal changes, involvement of industrial/agricultural activities. For example, the ground water has high temperature in winter and less temperature in summer. Less temperature of ground water is due to industrial waste addition.

Not much variations in quality of raw water at all the five locations are observed.

4.3.2 Analysis of treated water from purifiers:

The treated water from aquaguard has pH 7.5, hardness around 190mg/l, lesser TSS (235mg/l) and lessered nutrients (N & P).

The treated water from Green RO has hardness of 35mg/l($CaCO_3$).A less content of TDS and TSS is observed 108mg/l and 75mg/l respectively. Nutrient content was found low.

Pureit purifier produced treated water of pH 7.38, hardness of 200mg/l ($CaCO_3$) and TDS and TSS of 420 and 162mg/l. N and P removed were to a large extent.

Kent R.O. on an averaged generated water of pH 6.7, hardness of 25mg/l($CaCO_3$). Total suspended solids were at similar level of total dissolved solids. Nitrate and P content were 9mg/l and 0.06mg/l.

The aquafresh was capable of producing treated water at pH 7.54, Hardness 37mg/l $CaCO_3$. TDS were larger than TSS in value. MPN residual was at 6no./100ml (table 4.7).

Data shown in table 4.1-4.6 indicates that the behaviour of purifiers was not the same during the period of study. The variations could be attributed to operation and maintenance taken up by residents.

Table 4.1: Characterization of water (raw and treated) obtained in 1st sample

Parameters	Raw	Aquaguard	Raw	Green RO	Raw	Pureit	Raw	Kent	Raw	Aquafresh
pH	7.14	7.3	7.34	6.96	7.34	7.4	7.53	7.19	7.74	7.5
HARDNESS(mg/l) TOTAL permanenet temporary	 226 120 106	 214 100 114	 220 124 96	 62 20 38	 220 124 96	 186 18 168	 204 30 174	 16 10 6	 168 44 124	 40 20 20
TDS (mg/l)	200	100	892	398	892	188	430	248	300	130
TSS(mg/l)	982	798	1000	152	1000	310	1148	400	818	200
PHOSPHATE(mg/l)	0.0403	0.033	0.0310	0.022	0.0310	0.0507	0.036	0.036	0.0494	0.0663
CHLORIDE(mg/l)	47	39	45	32	45	40	41	23	30	23
TURBIDITY(NTU)	20.6	14.2	21.8	13.4	21.8	19.0	05.5	3.8	22.2	20
DO(mg/l)	3.5	9.2	8.3	8.6	8.3	8.4	8.3	8.6	9.6	10.7
MPN	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	39/100ml	11/100ml

Table 4.2 : Characterization of water (raw and treated) obtained in 2nd sampling

PARAMETERS	Raw	Aquaguard	Raw	RO	Raw	Pureit	Raw	Kent	Raw	AQUAFRESH
pH	7.2	7.84	7.35	7.28	7.35	7.62	7.24	6.69	7.3	7.4
HARDNESS(mg/l) TOTAL TEMPORARY PERMANENT	 60 40 20	 200 20 280	 230 120 110	 52 10 42	 230 120 110	 184 24 160	 200 35 165	 14 10 4	 196 38 158	 28 10 18
TDS(mg/l)	205	103	880	24	880	4	435	290	290	22
TSS(mg/l)	982	62	980	230	980	284	1179	500	810	188
PHOSPHATE(mg/l)	0.044	0.043	0.040	0.039	0.040	0.079	0.042	0.053	0.048	0.0416
CHLORIDE(mg/l)	69	51	43	13	43	38	51	4	14	9
TURBIDITY	20.6	14.2	21.1	06.3	21.1	19.0	05.5	4	22.2	20.15
DO(mg/l)	9.0	9.4	8.1	9.1	8.1	9.7	7.1	12.0	6.6	8.0
NITRATE(mg/l)	21.1	17.1	20.85	7.3	20.85	16.85	18	6.25	45.89	18.55
MPN	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	39/100ml	4/100ml
FLOURIDE(mg/l)	0	0	0	0	0	0	0	0	0	0

Table 4.3: Characterization of water (raw and treated) obtained in 3rd sampling

Parameters	Raw	Aquaguard	Raw	Green RO	Raw	Pureit	Raw	Kent	Raw	Aquafresh
pH	7.92	8.01	7.74	7.56	7.74	7.57	7.24	6.65	7.35	7.46
Hardness(mg/l) total permanent temporary	 214 32 182	 188 22 166	 196 24 174	 26 10 16	 196 24 166	 202 40 162	 200 30 175	 18 11 7	 198 36 162	 40 16 24
TDS(mg/l)	205	370	880	54	880	360	435	200	295	72
TSS(mg/l)	975	112	975	10	975	86	1000	96	800	218
Phosphate(mg/l)	0.22	0.067	0.50	0.48	0.50	0.054	0.152	0.068	0.80	0.200
Chloride(mg/l)	123	138	40	8	40	36	50	5	17	13
Turbidity(mg/l)	20.3	19	19.8	01.3	19.8	19.0	06.4	04.1	23.0	21.1
Do(mg/l)	8.9	9.3	8.3	8.7	8.3	9.2	7.1	10	6.6	8.0
Nitrate(mg/l)	21.0	16	20.25	5.32	20.25	19.15	18.6	9.85	7.95	8.55
Fluoride(mg/l)	0	0	0	0	0	0	0	0	0	0
MPN	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	39/100ml	4/100ml

Table 4.4 : Characterization of water(raw and treated) from obtained in 4th sampling.

PARAMETERS	Raw	Aquaguard	Raw	Green RO	Raw	Pureit	Raw	Kent	Raw	Aquafresh
pH	7.1	7.3	7.7	7.49	7.7	7.27	7.3	6.5	7.3	7.5
HARDNESS(mg/l) TOTAL PERMANENT TEMPORARY	 216 25 191	 208 16 192	 190 30 160	 28 24 4	 190 30 160	 220 44 176	 210 35 175	 30 17 13	 190 40 150	 43 16 27
TDS(mg/l)	210	400	890	56	890	385	444	235	290	75
TSS(mg/l)	890	130	959	14	959	95	980	105	810	224
Phosphate(mg/l)	0.22	0.022	0.52	0.029	0.52	0.22	0.160	0.080	0.81	0.24
Chloride(mg/l)	100	140	46	10	46	40	54	10	17.4	15
Turbidity	20.3	19.2	18.9	02.1	18.9	18.7	08.0	05.8	23.4	21.8
Do(mg/l)	9.0	9.2	8.2	8.6	8.2	9.1	7.3	9.7	6.7	8.1
Nitrate(mg/l)	22.0	21.7	20.3	9.45	20.3	22.7	17.9	9.92	7.9	8.5
Fluoride(mg/l)	0	0	0	0	0	0	0	0.13	0	0
MPN	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	39/100ml	4/100ml

Table 4.5 : Characterization of water (raw and treated) obtained in 5th sampling

PARAMETERS	Raw	Aquaguard	Raw	Green RO	Raw	Pureit	Raw	Kent	Raw	Aquafresh
Ph	7.2	7.4	7.5	7.1	7.5	7.27	7.32	6.8	7.34	7.6
HARDNESS(mg/l) TOTAL PERMANENT TEMPORARY	 222 30 192	 214 16 198	 188 33 155	 29 26 3	 188 33 55	 225 48 177	 210 38 172	 32 19 13	 183 35 148	 46 19 27
TDS(mg/l)	219	450	888	58	888	392	448	258	293	79
TSS(mg/l)	990	158	971	19	971	102	983	111	814	231
Phosphate(mg/l)	0.23	0.026	0.52	0.033	0.52	0.29	0.158	0.078	0.83	0.30
Chloride(mg/l)	102	144	43	14	43	40	56	12	17.9	16
Turbidity(NTU)	20.31	19.8	19.0	02.3	19.0	18.7	08.2	06.1	23.4	22.09
Do(mg/l)	9.0	9.3	7.9	8.1	7.9	8.9	7.3	9.4	7.0	8.0
Nitrate(mg/l)	22.4	21.9	21.0	9.8	21.0	22.9	18.01	9.94	7.88	8.72
Fluoride(mg/l)	0	0	0	0	0	0	0	0.15	0	0
MPN	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	39/100ml	7/100ml

Table 4.6 : Characterization of water (raw and treated) obtained in 6th sampling

PARAMETERS	Raw	Aquaguard	Raw	Green RO	Raw	Pureit	Raw	Kent	Raw	Aquafresh
pH	7.2	7.42	7.5	7.2	7.5	7.2	7.32	6.9	7.34	7.8
HARDNESS(mg/l) TOTAL PERMANENT TEMPORARY	 222 30 192	 222 22 200	 188 33 155	 24 21 3	 188 33 55	 232 50 182	 210 38 172	 40 18 22	 183 35 148	 28 12 16
TDS(mg/l)	219	480	888	60	888	400	448	271	293	80
TSS(mg/l)	990	160	971	23	971	100	983	134	814	235
Phosphate(mg/l)	0.23	0.026	0.52	0.045	0.52	0.33	0.158	0.092	0.83	0.29
Chloride(mg/l)	102	150	43	19	43	41	56	14	17.9	16.2
Turbidity(NTU)	20.31	19.8	19.0	02.3	19.0	20.0	08.2	07.3	23.4	23.1
Do(mg/l)	9.0	9.2	7.9	8.0	7.9	8.6	7.3	9.2	7.0	8.4
Nitrate(mg/l)	22.4	22	21.0	11	21.0	24	18.01	9.99	7.88	8.8
Fluoride(mg/l)	0	0	0	0	0	0	0	0.17	0	0
MPN	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	39/100ml	7/100ml

As an instance ,the kent R.O. was 6months ,Green R.O. was 2 years and aquafresh was 6years prior installed prior to study. Similar variations are shown in Fig 4.1-4.5.

Variation of quality parameters in treated water from aquaguard

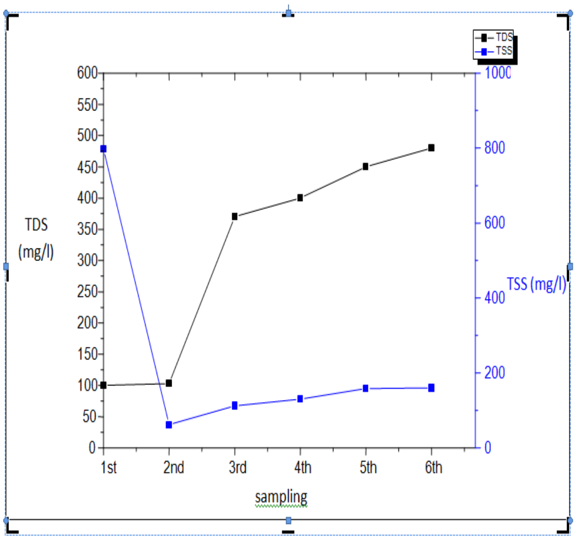

Fig 4.1(a) variation of TDS and TSS.

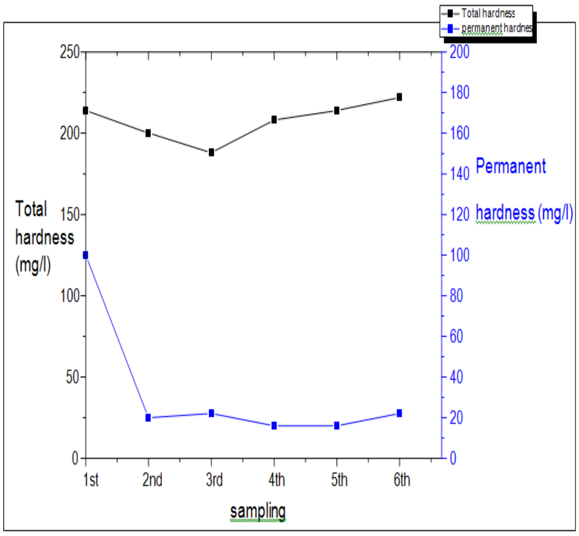

Fig 4.1(b) Variation of total and permanent hardness.

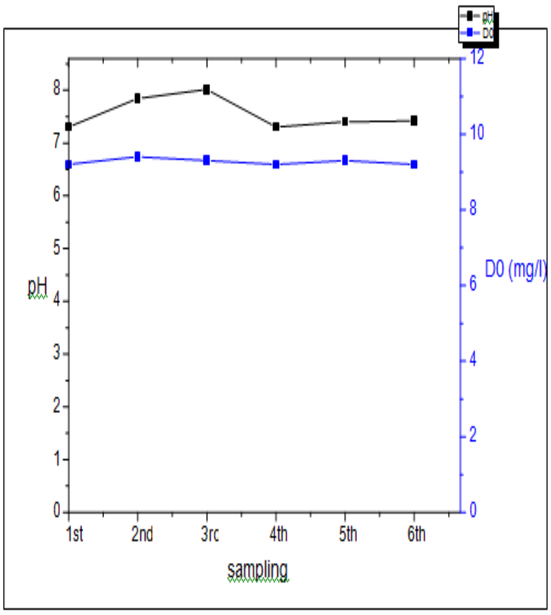

Fig 4.1(c) variation of DO and pH.

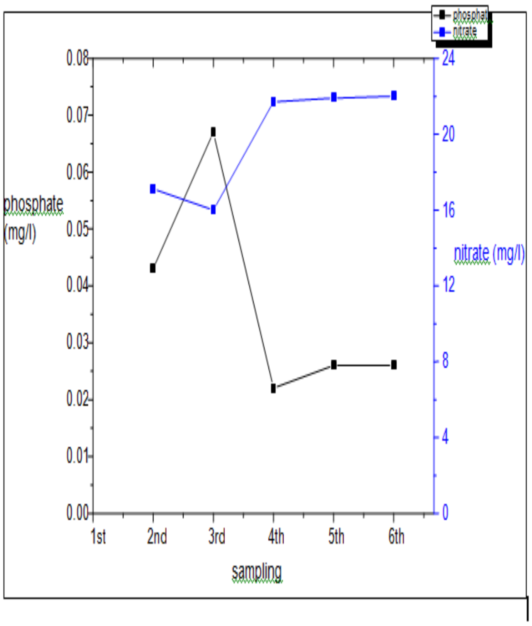

Fig 4.1(d) variation of phosphate and nitrate.

Variation of quality parameters in treated water from Green R.O.

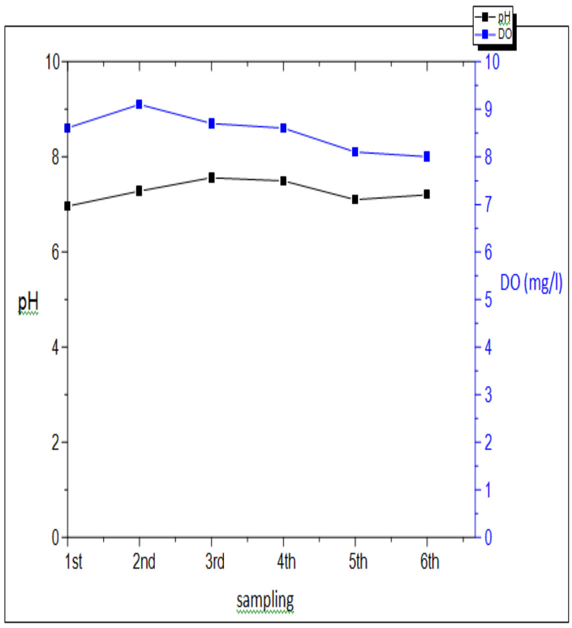

Fig 4.2(a) variation of pH and DO.

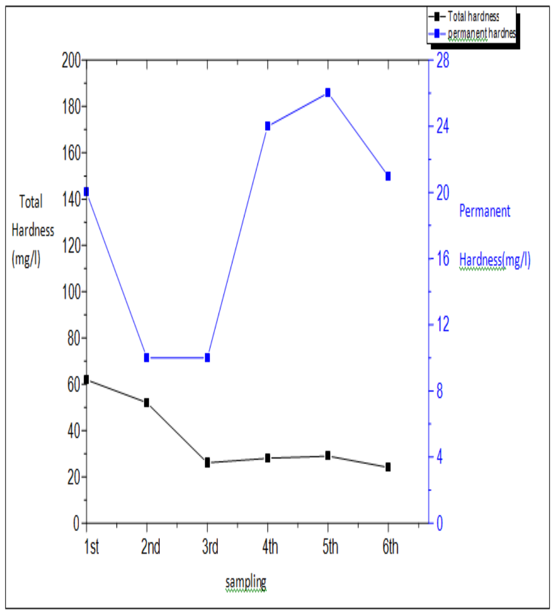

Fig 4.2(b) variation of total and permanent hardness.

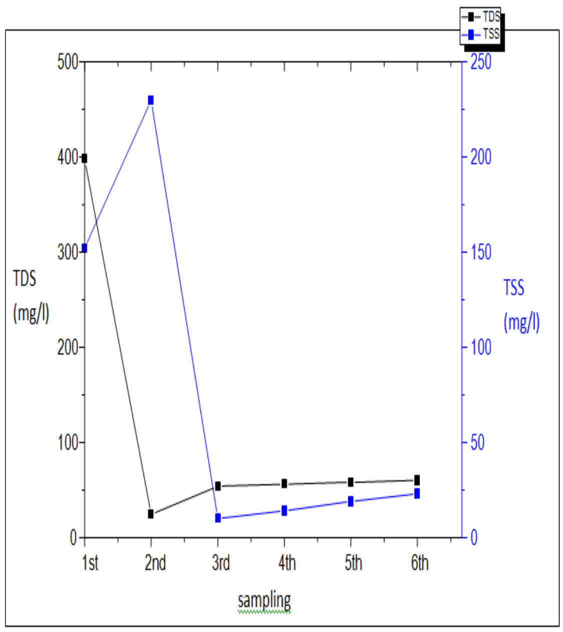

Fig 4.2(c) variation of TDS and TSS.

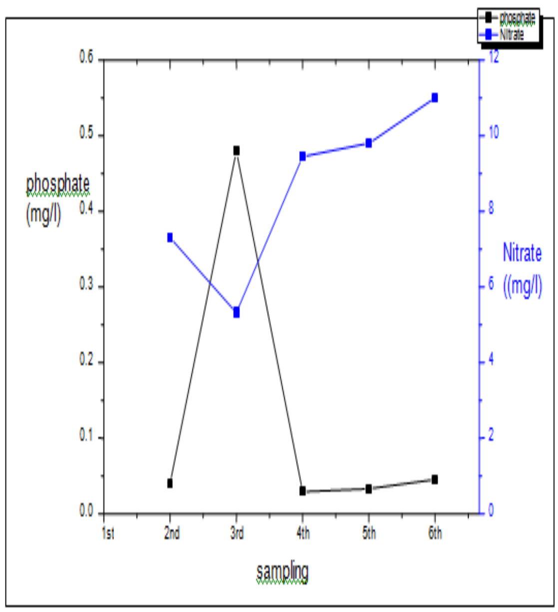

Fig 4.2(d) variation of phosphate and nitrate.

Variation of quality parameters in treated water from Pureit

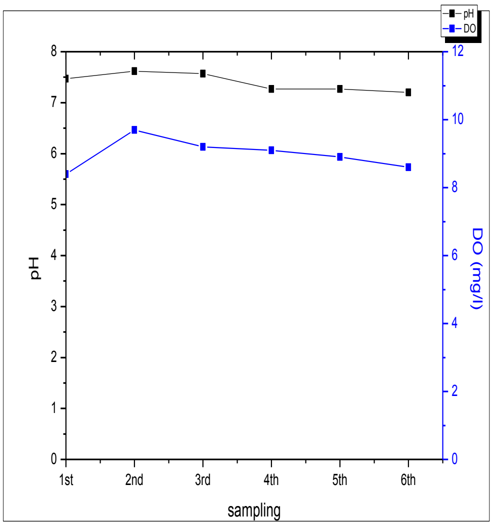

Fig4.3(a) variation of pH and DO.

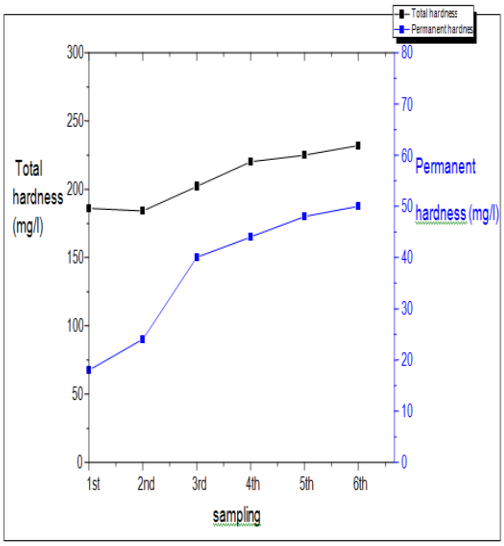

Fig4.3(b) variation of total and permanent hardness

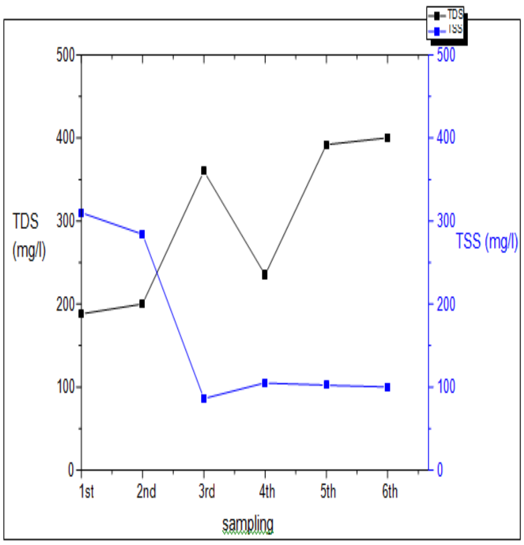

Fig4.3(c) variation of TDS and TSS.

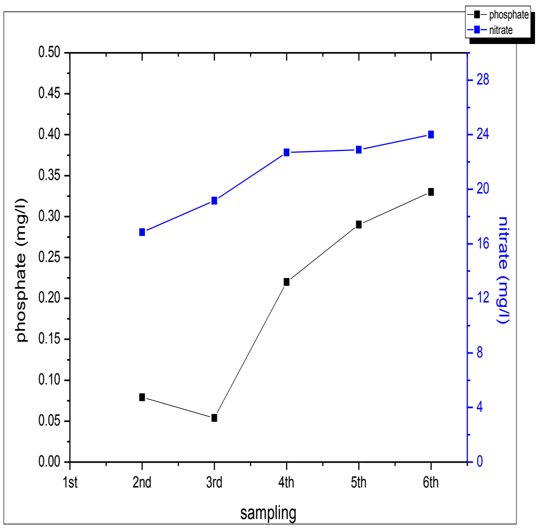

Fig4.4(d) Variation of phosphate and nitrate.

Variation of quality parameters in treated water from kent

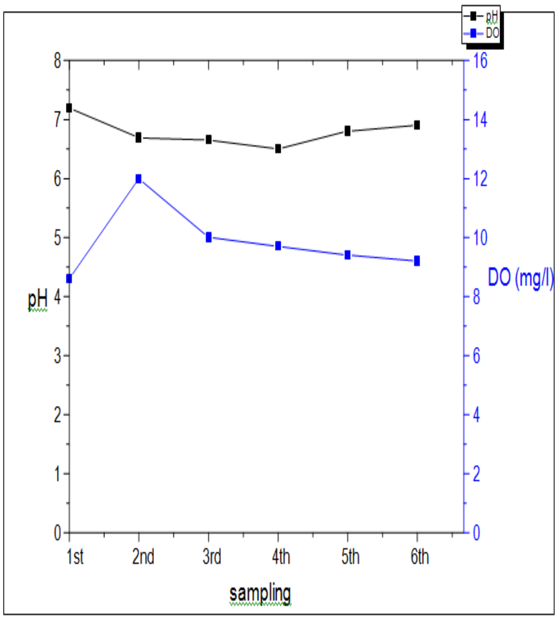

Fig4.4(a) variation of pH and DO.

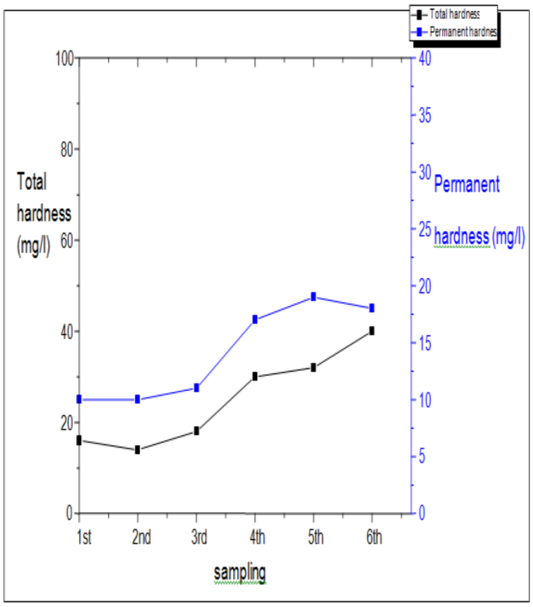

Fig4.4(b) variation of total and permanent hardness

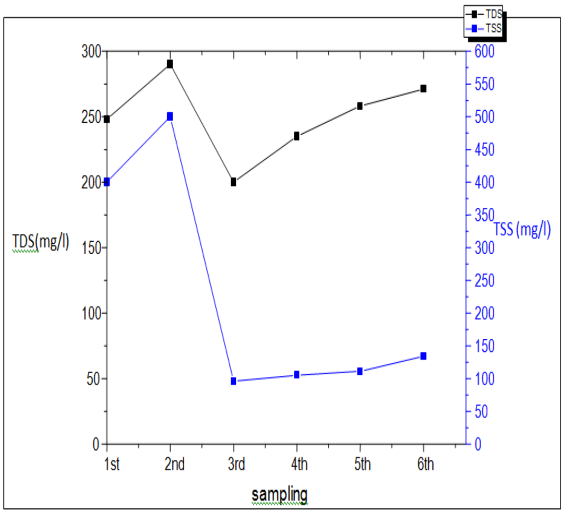

Fig 4.4(c)variation of TDS and TSS.

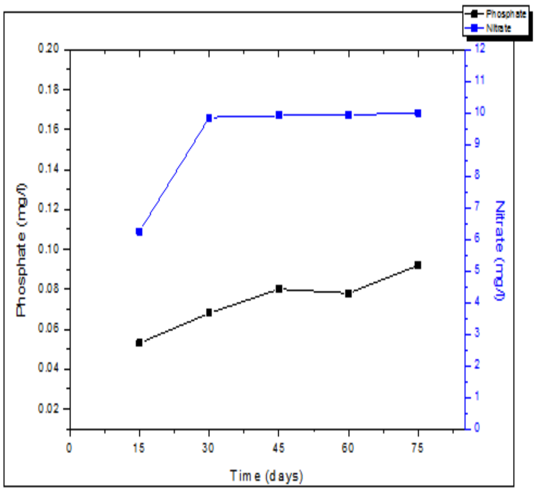

Fig4.4(d) variation of phosphate and nitrate.

Variation of quality parameters in treated water from Aquafresh.

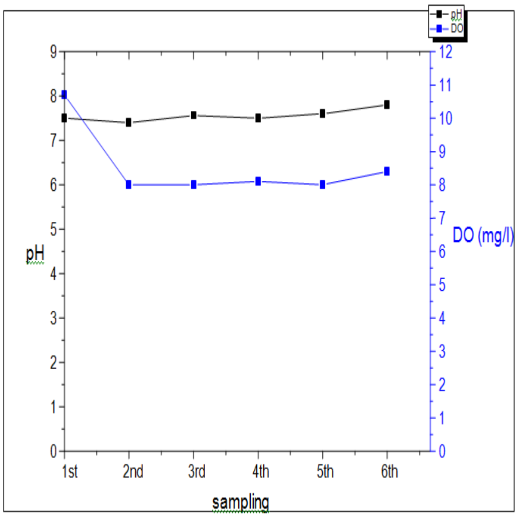

Fig4.5(a) variation of pH and DO.

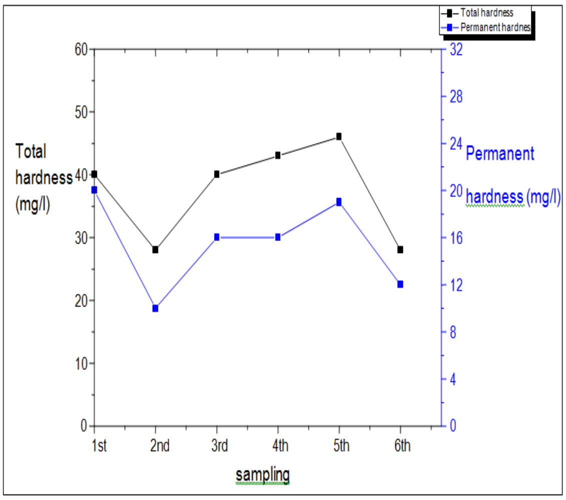

Fig4.5(b) variation of total and permanent hardness.

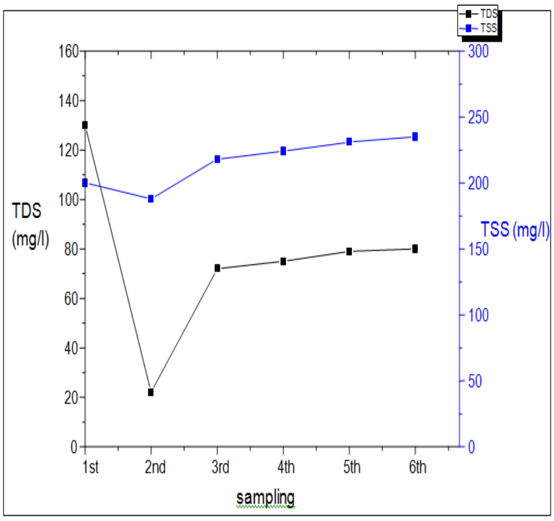

Fig4.5(c) variation of TDS and TSS.

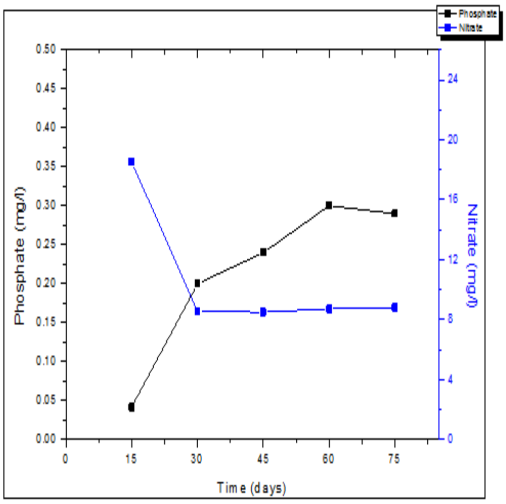

Fig4.5(d) variation of phosphate and nitrate.

4.3.3. Comparison of performance of purifiers:

Aquaguard purifier was incapable of reducing hardness. Green R.O. and Kent R.O. generated water with pH lower than raw water. It is worthy to mention here that RO membranes reject dissolved ions but not dissolved gases. The equilibrium shift among CO_3^{2},HCO_3^- & CO_2 is the contributing reason for the decline. The same fact was observed with the performance of Kent R.O. purifier. These two could remove hardness. Pureit showed better to maximum extent ability in removing most of the contaminants. However the extent was lower in compared to R.O. filters. The aquafresh purifier could not be successful in eliminating MPN completely.

The increased DO levels in treated water (compared to raw water) with all the purifiers is possibly due to absence of micro organisms, which otherwise would have exhausted it. The nitrate level in raw water was well below a standard of 45mg/l. So its further removal is not targeted in purifiers. (Table 4.7)

Table 4.7 : Average characteristics of water and treated water

parameters	Raw water	From aquaguard	Raw water	From Green R.O.	Raw water	From pureit	Raw water	From Kent	Raw Water	From Aquafresh
pH	7.29	7.54	7.52	7.26	7.52	7.38	7.32	6.7	7.3	7.54
Hardness(mg/l)										
Total	193.33	207.66	202	36.83	202	208.16	205.66	25	186.3	37.5
Permanent	46.16	62.83	60.6	18.5	60.6	35.66	34.33	14.16	38	15.5
Temporary	147.16	191.66	141.6	17.66	141.66	170.83	172.16	10.8	148.3	22
TDS(mg/l)	209.66	317.16	886.3	108.3	886.33	420.83	440	250.33	293.5	76.3
TSS(mg/l)	968.16	236.66	976	74.66	976	162.83	1045.5	224.33	811	216
Phosphate(mg/l)	0.164	0.036	0.355	0.151	0.355	0.17	0.117	0.067	0.56	0.189
Chloride(mg/l)	90.5	110.33	43.33	16	43.33	39.16	51.33	8.16	19	15.36
Turbidity(NTU)	20.40	17.7	19.9	4.6	19.9	19	6.9	5.18	22.93	21.37
DO(mg/l)	8.06	9.26	8.1	8.51	8.1	8.9	7.4	9.8	7.25	8.5
Nitrate(mg/l)	21.79	19.74	20.68	8.57	20.68	21.12	18.10	9.19	15.3	10.6
Flouride(mg/l)	0	0	0	0	0	0	0	0.15	0	0
MPN	nil	Nil	nil	nil	nil	nil	nil	nil	39/100ml	6/100ml

Mwabi et al., (2011) assessed the performance of filters in terms of removal of F-,Ca and Mg, nitrate and phosphate and also microbial count. Samantray et al., (2009) characterised the Mahanadi and its distribution in different seasons. Pritchard et al. (2007) while working on shallow wells of Malawi observed higher values of coliform in the wet season compared to those of dry season. Abbaszadegan (1996) evaluated the disinfection efficacy against water borne pathogens.

4.4 Performance of purifiers-WQI

Analysis of raw water and treated water from the purifier involved much data. Hence, efforts are made to aggregate the above information to water quality Index (WQI). The opinion of experts in assigning the weightage to quality parameters and drinking water quality standards proposed by WHO are considered in arriving at WQI for raw water and treated water. The WQI values are shown in table 4.9-4.18. WQI of the treated water from all the five purifiers were smaller than that of raw water. This indicated the purifier were involved in significant removal of water pollutants. Very high WQI values could be presumably due to subjectivity etc., involved in assigning weightage to parameters.

Singla et al., (2011) evaluated the water quality data of Doon valley in terms of WQI. Parmar and Parmar, (2010) developed WQI by considering six water quality parameters and used a five point rating scale to classify the water.

Table 4.8: WHO standards for drinking water

Parameters	Value
pH	8.5
Hardness	300mg/l
TDS	500mg/l
TSS	500mg/l
Phosphate	250mg/l
Chloride	100mg/l
Turbidity	10NTU
DO	5mg/l
Flouride	1mg/l
Nitrate	45mg/l

Table 4.9 : WQI for raw water at aquaguard purifier

	A	B	C	D	E	F	G	H
1	parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt. (Vn)R/A.G	qn=Vn/Vs	Wn*qn	WQI for R/A.G
2	pH	8.5	1	0.033333333	7.92	0.931764706	0.031058824	70.62
3	Hardness	300	1	0.033333333	214	0.713333333	0.023777778	
4	TDS	500	3	0.1	205	0.41	0.041	
5	TSS	500	4	0.133333333	975	1.95	0.26	
6	phosphate	250	2	0.066666667	0.22	0.00088	5.86667E-05	
7	chloride	100	3	0.1	123	1.23	0.123	
8	turbidity	10	4	0.133333333	20.3	2.03	0.270666667	
9	DO	5	5	0.166666667	8.9	1.78	0.296666667	
10	Flouride	1	4	0.133333333	-2.9	-2.9	-0.386666667	
11	Nitrate	45	3	0.1	21	0.466666667	0.046666667	
12			30					

Table 4.10 :WQI for purified water by aquaguard

Parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt. (Vn)/A.G	qn=Vn/Vs	Wn*qn	WQI for A.G
pH	8.5	1	0.033333333	8.01	0.942352941	0.031411765	55.4740742
Hardness	300	1	0.033333333	188	0.626666667	0.020888889	
TDS	500	3	0.1	205	0.41	0.041	
TSS	500	4	0.133333333	112	0.224	0.029866667	
phosphate	250	2	0.066666667	0.067	0.000268	1.78667E-05	
chloride	100	3	0.1	138	1.38	0.138	
turbidity	10	4	0.133333333	19	1.9	0.253333333	
DO	5	5	0.166666667	9.3	1.86	0.31	
Flouride	1	4	0.133333333	-2.29	-2.29	-0.30533333	
Nitrate	45	3	0.1	16	0.355555556	0.035555556	
		30					

Table 4.11: WQI for raw water at green R.O. purifier

parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt.(Vn)..green ro	qn=Vn/Vs	Wn*qn	WQI for green ro
pH	8.5	1	0.033333333	7.74	0.910588235	0.030352941	375.7819608
Hardness	300	1	0.033333333	196	0.653333333	0.021777778	
TDS	500	3	0.1	880	1.76	0.176	
TSS	500	4	0.133333333	975	1.95	0.26	
phosphate	250	2	0.066666667	0.5	0.002	0.000133333	
chloride	100	3	0.1	40	0.4	0.04	
turbidity	10	4	0.133333333	19.8	1.98	0.264	
DO	5	5	0.166666667	8.3	1.66	0.276666667	
Flouride	1	4	0.133333333	20.25	20.25	2.7	
Nitrate	45	3	0.1	-5	-0.111111111	-0.011111111	
		30					

Table 4.12 : WQI for treated water by green RO purifier

parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt.(Vn)..g	qn=Vn/Vs	Wn*qn	WQI for green ro
pH	8.5	1	0.033333333	7.56	0.889411765	0.029647059	106.5775059
Hardness	300	1	0.033333333	26	0.086666667	0.002888889	
TDS	500	3	0.1	54	0.108	0.0108	
TSS	500	4	0.133333333	10	0.02	0.002666667	
phosphate	250	2	0.066666667	0.48	0.00192	0.000128	
chloride	100	3	0.1	8	0.08	0.008	
turbidity	10	4	0.133333333	1.3	0.13	0.017333333	
DO	5	5	0.166666667	8.7	1.74	0.29	
Flouride	1	4	0.133333333	5.32	5.32	0.709333333	
Nitrate	45	3	0.1	-2.26	-0.050222222	-0.005022222	
		30					

Table 4.13 : WQI for raw water at pureit purifier

parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt.(Vn)..green ro	qn=Vn/Vs	Wn*qn	WQI for green ro
pH	8.5	1	0.033333333	7.74	0.910588235	0.030352941	375.7819608
Hardness	300	1	0.033333333	196	0.653333333	0.021777778	
TDS	500	3	0.1	880	1.76	0.176	
TSS	500	4	0.133333333	975	1.95	0.26	
phosphate	250	2	0.066666667	0.5	0.002	0.000133333	
chloride	100	3	0.1	40	0.4	0.04	
turbidity	10	4	0.133333333	19.8	1.98	0.264	
DO	5	5	0.166666667	8.3	1.66	0.276666667	
Flouride	1	4	0.133333333	20.25	20.25	2.7	
Nitrate	45	3	0.1	-5	-0.111111111	-0.011111111	
		30					

Table 4.14 : WQI for purified water by pureit purifier

parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt.(Vn)..pureit	qn=Vn/Vs	Wn*qn	WQI for pureit
pH	8.5	1	0.033333333	7.57	0.890588235	0.02968627	328.085623
Hardness	300	1	0.033333333	202	0.673333333	0.02244444	
TDS	500	3	0.1	360	0.72	0.072	
TSS	500	4	0.133333333	86	0.172	0.02293333	
phosphate	250	2	0.066666667	0.054	0.000216	0.0000144	
chloride	100	3	0.1	36	0.36	0.036	
turbidity	10	4	0.133333333	19	1.9	0.25333333	
DO	5	5	0.166666667	9.2	1.84	0.30666667	
Flouride	1	4	0.133333333	19.15	19.15	2.55333333	
Nitrate	45	3	0.1	-7	-0.155555556	-0.0155556	
		30	1				

Table 4.15: WQI for raw water at kent R.O.

parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt.(Vn)..R.kent	qn=Vn/Vs	Wn*qn	WQI for R.kent
pH	8.5	1	0.033333333	7.24	0.851764706	0.028392	55.0988246
Hardness	300	1	0.033333333	200	0.666666667	0.022222	
TDS	500	3	0.1	435	0.87	0.087	
TSS	500	4	0.133333333	1000	2	0.266667	
phosphate	250	2	0.066666667	0.152	0.000608	4.05E-05	
chloride	100	3	0.1	50	0.5	0.05	
turbidity	10	4	0.133333333	6.4	0.64	0.085333	
DO	5	5	0.166666667	7.1	1.42	0.236667	
Flouride	1	4	0.133333333	-2	-2	-0.26667	
Nitrate	45	3	0.1	18.6	0.413333333	0.041333	
		30	1				

Table 4.16 :WQI for purified water by KENT R.O.

parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt.(Vn)..kent	qn=Vn/Vs	Wn*qn	WQI for KENT
pH	8.5	1	0.033333333	6.65	0.782352941	0.026078431	179.8007673
Hardness	300	1	0.033333333	18	0.06	0.002	
TDS	500	3	0.1	200	0.4	0.04	
TSS	500	4	0.133333333	96	0.192	0.0256	
phosphate	250	2	0.066666667	0.068	0.000272	1.81333E-05	
chloride	100	3	0.1	5	0.05	0.005	
turbidity	10	4	0.133333333	4.1	0.41	0.054666667	
DO	5	5	0.166666667	10	2	0.333333334	
Flouride	1	4	0.133333333	9.85	9.85	1.31333333	
Nitrate	45	3	0.1	-0.91	-0.020222222	-0.002022222	
		30	1				

Table 4.17 :WQI for raw water at Aquafresh

parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt Vn--r.a.f	qn=Vn/Vs	Wn*qn	WQI
pH	8.5	1	0.033333333	7.35	0.86470588	0.028824	191.5925752
Hardness	300	1	0.033333333	198	0.66	0.022	
TDS	500	3	0.1	295	0.59	0.059	
TSS	500	4	0.133333333	800	1.6	0.213333	
phosphate	250	2	0.066666667	0.8	0.0032	0.000213	
chloride	100	3	0.1	17	0.17	0.017	
turbidity	10	4	0.133333333	23	2.3	0.306667	
DO	5	5	0.166666667	6.6	1.32	0.22	
Flouride	1	4	0.133333333	7.95	7.95	1.06	
Nitrate	45	3	0.1	-5	-0.11111111	-0.01111	
		30					

Table-4.18 WQI for purified water by aquafresh

parameters	WHO standards (Vs)	weightage	relative weight(Wn)	actual amt. (Vn)..A.f	qn=Vn/Vs	Wn*qn	WQI
pH	8.5	1	0.033333333	7.46	0.87764706	0.0292549	179.595268
Hardness	300	1	0.033333333	40	0.13333333	0.00444444	
TDS	500	3	0.1	72	0.144	0.0144	
TSS	500	4	0.133333333	218	0.436	0.05813333	
phosphate	250	2	0.066666667	0.2	0.0008	5.3333E-05	
chloride	100	3	0.1	13	0.13	0.013	
turbidity	10	4	0.133333333	21.1	2.11	0.28133333	
DO	5	5	0.166666667	8	1.6	0.26666667	
Flouride	1	4	0.133333333	8.55	8.55	1.14	
Nitrate	45	3	0.1	-5.1	-0.11333333	-0.01133333	
		30					

CHAPTER 5

CONCLUSION

Based on the study done on performance evaluation of domestic water purifiers ,the following conclusion are drawn.

- The stages involved with each purifier for water treatment is different. The design involved should be a holistic approach considering the maximum removal of contaminants. Besides, the installation, operation and maintenance of the units are to be brought down keeping the convenience of the residents.

- Raw water available at residence-5 at Anand Nagar, Patiala is more unhygienic than that at other residences suggesting a better degree of treatment prior to usage.

- Although individual purifiers are capable of eliminating specific water pollutant. Green RO unit shows the highest degree of removal of the contaminants, suggesting its more appropriateness for adoption in the individual houses.

- WQI calculations aggregated the performance of purifiers in treating the water and the values for treated water were smaller than those of raw water, suggesting that adequate treatment took place.

FUTURE SCOPE:-

- A market survey of purifiers available may be their technical specifications collected and the perception of the users through a questionnaire generated.
- Correlation may be achieved among the various stages of treatment and the level of contaminants removed. More focus may be given to look at operation and maintenance troubles of each purifier.

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