

Study

to

Assess & Analyze Status of Water Purification Technologies in India

Supported & Catalyzed by:

GOVERNMENT OF INDIA
Ministry of Science & Technology
Department of Science & Technology
Water Technology Initiative (WTI)

Conducted by:



National Foundation of Indian Engineers

PREFACE

Water Technology Initiative (WTI), Department of Science & Technology, Ministry of Science & Technology, Government of India entrusted National Foundation of Indian Engineers (**NAFEN**) to undertake the study entitled “**To Assess & Analyze the Status of Water Purification Technologies in India**”.

The study intends to assess the status of various drinking water purification technologies on all India basis through identified sample from the Manufacturers of Water Purification Systems, R&D Labs. and Community Systems.

Data has been collected from 204 Manufacturing Organisations; 10 R&D Labs and 40 Community Users like MCDs, Panchyati Raj Institutions, PHEDs and Jal Nigams/Boards etc.

The study has been divided into Five Sections; **Section -1**: About the Study, which includes Introduction, Objective, Scope, Universe & Sample, Methodology, Brief Details of various Water Treatment Technologies, General Effectiveness of Various Water Treatment Technologies, Over view of Contaminants / Substances Removal Technology- wise, Time Period , Limitations and References; **Section -2**: Analysis for Manufacturing Organisations; **Section -3**: Analysis for Community Users; **Section -4**: Analysis for R&D Labs; **Section -5**: Annexures.

Through out the working on this study, the main aim had been to carry out meaningful and informative analysis of various drinking water purification technologies. We sincerely hope that the results of this study will be useful to all the concerned departments, policy planners, decision makers, industry, potential entrepreneurs and various research agencies of the country.

New Delhi
15th March, 2010


Dr. P K GUPTA
Project Investigator

ACKNOWLEDGEMENTS

At the outset, NAFEN would like to specially thank **Dr. Laxman Prasad**, Advisor & Head, Technology Mission, Department of Science & Technology (DST), for his guidance, motivation and sparing his valuable time for chairing the Local Project Advisory Committee Meetings held during the course of this study.

We specially acknowledge with thanks the guidance and expert advice given by **Prof. Dr. Arunabha Majumder** renowned scientist and environmentalist and former Director, All India Institute of Hygiene & Public Health, Gol in finalizing the report.

NAFEN is equally grateful to **Dr. Sanjay Bajpai, Director / Scientist "F"** and **Mr. Vineet Saini, Scientist "C"** and his team of WTI. Without their co-operation and guidance from time to time, it would not have been possible for NAFEN to complete this study.

NAFEN is also deeply obliged to all the members of the Local Project Advisory Committee (LPAC) and various other experts who participated in the meetings and all the respondents (Manufacturing Organizations, R&D Labs., State Municipal Corporations, Panchyati Raj Institutions, PHEDs & Jal Nigams/ Boards) for giving valuable information as per the structured questionnaire for completing the study in time.

We are thankful to all our colleagues in NAFEN, who helped NAFEN in completing this study within the stipulated time period.

New Delhi
15th March, 2010


Dr. P K GUPTA
Project Investigator

LOCAL PROJECT ADVISORY COMMITTEE

A Local Project Advisory Committee (LPAC) was constituted to advice and guide NAFEN from time to time during the execution of the study. The composition of the LPAC was as follows:-

Chairman

Dr. Laxman Prasad, Advisor & Head, Technology Mission, DST

Members

Dr. Sanjay Bajpai, Director/ Scientist F, WTI, DST

Mr. Vineet Saini, Scientist "C", WTI, DST

Prof. V. Subramaniam, Jawahar Lal Nehru University, New Delhi

Dr. K. Shipra Mishra, Additional Director, Defence Institute of Physiology & Allied Sciences, Delhi

Dr. Anshuman, Associate Fellow (WRP&M), TERI, New Delhi

Dr. K. Vijaya Lakshmi, Vice President, Development Alternatives, New Delhi

Mr. Mohinder Singh, Chief Engineer (WW-I), Delhi Jal Board, Delhi

Mr. Yogesh Chandra, V.P. Operations, Kent Water Filter System P. Ltd, Noida, U.P.

Mr. Murari Ratnam, Director, Central Soil & Materials Research Station New Delhi

Dr. D.S. Tewari, Former Advisor, DST

Mr. Lalit Wadhwa, Vice President Eureka Forbes, New Delhi

Mr. Manish Gandhi, General Manager (North Operations), Ion Exchange (India) Limited, New Delhi

Member Secretary

Prof. (Dr.) P.K. Gupta, Project Investigator & Secretary General, NAFEN

Mr. Rishi Kumar, Project Co-Investigator & Vice President, NAFEN

SECTION -1: ABOUT THE STUDY

1.0 INTRODUCTION

There is no doubt that water and sustainable development are inextricably linked. Once viewed as an infinite and bountiful resource, water today defines human, social and economic development. Without adequate supplies and management of fresh water resources, socio-economic development simply cannot take place.

If we look at the present scenario, we are leading towards crisis. About 85 % of rural population in India is solely dependent on ground water, which is depleting at a fast rate. In the urban areas though about 60% of the population is dependent on surface water sources, the availability and quality are questionable.

Population growth is expected to result in a decline in the per capita availability of fresh water: In 1947, this was measured at 5150 m³. By the year 2000, it was around 2200 m³. It has been recently estimated that by 2017 India will be 'water stressed' - per capita availability will decline to 1600 m³. Municipal water treatment today is essentially the same as it was over 100 years ago. Water is flown through sand beds to remove visible particles and then bleach (chlorine) is added to kill most of the bacteria.

Water is our body's only means of purifying itself. If our water already contains chemical contaminants, our body is unable to use it to its full benefit. When the risk is so great and the solution is so simple why chance it?

Around 37 million Indians are affected by water borne diseases annually and around 73 million working days are lost due to water borne diseases each year. The resulting economic burden is estimated at 600 million dollars a year.

The provision of clean drinking water has been given priority in the constitution of India, with Article 47 conferring the duty of providing clean drinking water and improving public health standards to the State.

As mentioned above, In India, 85% rural habitations are dependent on groundwater. Normally groundwater is safe for drinking but chemical contaminations of ground water have been reported from many areas in the country. Presence of excess fluoride, arsenic, salinity, iron, nitrate etc. are area specific and causes of contamination are mostly natural and geogenic but not anthropogenic. In India, 85% fresh water is used in agriculture; 10% water is used in Industries and Power generation sectors. The rest quantum of fresh water is used in public water supply. As fresh water is a limited resource, with the increasing demand in agriculture, industry etc, the per capita availability of the water is sharply declining in the country. Water stress as well as water acute conditions have been reached in many places in the country.

Some data about Water Resources and Utilization is as follows:-

- India has 16 per cent of the world population and 4 percent of its fresh water resources.
- Estimates indicate that surface and ground water availability is around 1869 billion cubic meters (BCM). Of this, 40 percent is not available for use due to geological and topographical reasons.
- Around 4000 BCM of fresh water is available due to precipitation in the form of rain and snow, most of which return to the seas via rivers.
- 92 percent groundwater extracted is used in the agricultural sector, 5 and 3 percent respectively for industrial and domestic sector.
- 89 percent of surface water use is for agriculture sector and 2 percent and 9 percent respectively are used by the industrial and domestic sector.

The purpose of the surveillance of drinking water supplies is to control the quality of the water and thereby protect the consumers. The sanitary deficiencies identified by such surveillance are not remedied, then the situation may become dangerous, because the faith of community in the system will be lost. As a result effective preventive and remedial measures with reliable advance warning system must be adopted.

Objective of water treatment is to produce adequate secured water that is physically, chemically, bacteriologically and aesthetically pleasing. More specifically, water treatment must produce water that is potable, safe, clear, color and odorless, reasonably soft, non -corrosive etc.

In India, urban water supply systems are operated & maintained by Urban Local Bodies (ULBs), Jal Boards, Water and Sanitation Authorities etc. Rural water supply is normally provided by PHEDs & PRIs. As drinking water quality has direct bearing on the health of the consumers and with the increasing awareness among the consumers, demand of household water treatment units is on the increase in cities & towns.

Household water purification units have been developed by different manufacturers and are available in the market. Prices of different units are dependent upon the technologies adopted for water purification. Though different household units are on sale in the market, there is no proper quality control system to evaluate the performance efficacy at the field level since water quality varies from place to place in the country

This study aims at to highlight the different technologies available in the market and targeted contaminants / substances removal from water. Report also highlights the tentative purification costs as well as operation & maintenance costs of different technologies.

It has been observed that in many areas where people are facing contaminants problems in drinking water e.g. arsenic, excess fluoride, iron etc., some local manufacturers have developed house hold Filters for removal of arsenic, excess fluoride and iron. Activated Alumina has been used for removal of arsenic and excess fluoride (Reference in West Bengal , domestic Filters for arsenic and excess fluoride removal have been developed under joint action plan of UNICEF and PHED, Kolkata. Similarly household Filters for removal of excess fluorides have been distributed in Bihar also. Carbon Filters using granulated activated carbon have also been found in the market for sale. The above information was collected during discussions with the experts and therefore details of such Filters have been included in the report.

1.1 **OBJECTIVE**

The objective of the study was:-

To Assess & Analyze the Status of Water Purification Technologies in India.

1.2 **SCOPE**

The Scope of the study covered following:-

- i. To Assess the Status of Water Purification Technologies in India from Manufactures of drinking water purification systems and R&D Labs., for house hold (<15 lph) and community systems (>15 - <500 lph) and (>500 - 5000 lph).
- ii. To analyze data from community users like Jal Nigams/ Boards, PHEDs, Municipalities and Panchyati Raj Institutions of capacities (>15-<500 lph) & (>500-5000 lph) from the following identified states:-

Bihar	Delhi	Haryana
Himachal Pradesh	Kerala	Maharashtra
Punjab	Rajasthan	Tamil Nadu
UP	West Bengal	

1.3 UNIVERSE & SAMPLE

Sr.No.	Category	Universe (Contacted by Mail)	Responding Organisations	Agreed Sample Size
1	Manufacturing Organisations	342	204	200
2	Community Users like Jal Nigams /Boards, Panchyati Raj Institutions, MCDs & PHEDs	50	40	40
3	R&D Labs	20	10	10

Sample has been selected on random basis state wise.

1.4 METHODOLOGY

Following methodology was adopted:

- I. Identified the manufacturing organizations engaged in the area of drinking water purification technologies and prepared the database.
- II. Identified and prepared a database of R&D Labs., dealing in water purification systems in consultation with the department.
- III. Prepared a database of users like Jal Nigams / Boards, PHEDs, Municipalities and Panchyati Raj institutions for community systems from the identified States.
- IV. Constituted Local Project Advisory Committee (LPAC) and held the first LPAC meeting on 16th March, 2009 to finalize the structured questionnaires.
- V. The questionnaires finalized in the first meeting of the LPAC, were circulated to various Manufacturing Organizations, Community Users like Municipal Corporations, Jal Boards, Public Health Engineering Departments and Panchyati Raj Institutions dealing with drinking water purification. Questionnaires were also sent to identified R&D Labs., who are engaged in the technology development for water purification.
- VI. Hosted the questionnaire at NAFEN web site www.nafenindia.com.
- VII. Collected data through personal visits.
- VIII. Data feeding and internal re-checking.
- IX. Data Analysis

Responses from various organizations were satisfactory. However some responses on the efficacy of the respective unit operations for water purification were found to be having discrepancies in certain

cases. Therefore, technologies adopted by different organizations were examined and variances were minimized through existing standard information.

The report highlights all the technologies available for water purification for House Hold Systems and Community Level Systems. Standard effectiveness of each of the technologies for removal of contaminants / substances from water has also been highlighted, with supporting data as supplied by the organizations.

- X. Draft Report
- XI. 2nd meeting of LPAC held on 3rd February, 2010 at New Delhi to consider the draft report
- XII. Final Report.

1.5 BRIEF DETAILS OF VARIOUS WATER TREATMENT TECHNOLOGIES

A. Pre-Treatment

It aims at removal of suspended and colloidal solids before filtration. To achieve optimal operation of filter, Pre-Treatment is normally essential.

i) Coagulation and Flocculation

- This process is used for removal of suspended and colloidal solids, specially for surface water.
- Coagulation is the destabilization of colloidal particles. The particles are essentially coated with a chemically sticky layer that allows them to flocculate (agglomerate) and settle in a reasonable period of time.
- Alum (Aluminium Sulphate), Ferric Sulphate, Sodium Aluminate, Poly Aluminium Chloride are mostly used by water supply agencies for community system.
- This process is considered as pre-treatment before Rapid Gravity (Sand) Filter.
- Coagulation and Flocculation is associated with sedimentation for allowing settling of flocs enmeshed with impurities.
- The unit where flocculation and sedimentation take place is known as CLARIFLOCCULATOR (widely used in water treatment plants in India).

ii) Sedimentation

- Sedimentation is the physical separation of suspended material from water by the action of gravity.
- If raw water turbidity is less (<30 NTU) normally plain sedimentation is used.

iii) **Tube and Lamella Clarifiers**

- Sedimentation efficiency could be enhanced through introduction of tube and lamella clarifiers.
- Tube and lamella clarifiers enhance surface area resulting in lower surface loading rate and higher sedimentation and solids removal.
- Tube settlers and plastic (PVC) modules with uniformly spaced inclined channels are placed.
- Lamella settlers have uniformly spaced inclined panels.
- Many organisations (PHEDs, Jal Boards, Municipal Corporations, Water Authority etc.) are introducing this technology in water purification for public water supply.

B. Filtration

The process removes suspended solids and micro-organisms from water. Removal in a filter is highly dependent on the surface area of the media particles. Normally sand and gravel are used as media. Multimedia Filter (anthracite coal, sand and gravel) are being used to get higher filtration efficiency. Filtration process may work either by gravity or by pressure. Accordingly they are termed as Gravity Filter or Pressure Filter.

I) Slow Sand Filter (Gravity)

- It consists of thick sand layer (medium size) placed on graded gravel layer and Filter under gravity.
- The rate of filtration is less (100-200 lts/hr per m² or 2.4 to 4.8 m³ /day per m²)
- Bacteria removal may be 99.8%.
- It does not require back washing. Scraping and cleaning of top sand surface are practiced between 60 and 90 days.
- Does not require electricity to operate.
- Extensively used for surface water treatment (hilly areas) where turbidity of raw water is less.

II) Rapid Sand Filter (Gravity)

- It consists of thick sand layer (Coarse Size) placed on graded gravel layer and Filter under gravity.
- The rate of filtration is higher (3000-6000 lts/hr per m² or 72 to 144 m³ /day per m²)

- Bacteria removal may be 99.6%.
- It requires backwashing for cleaning. The cleaning interval normally varies between 24 and 48 hrs.
- It requires electricity for operation.
- Extensively used for surface water treatment in India.

III) **Dual Media Filter (Gravity)**

- Anthracite and Sand are used as filter media and placed over gravel.
- The rate of filtration is higher than Rapid Sand/ Gravity filter (9000-12000 lts/hr per m² or 216-288 m³ /day per m²)
- Other features are more or less same with Rapid Sand Filter.
- This technology is being applied in India in water treatment plants.

IV) **Pressure Filter**

- Pressure Filters are enclosed usually in metal containers and can be operated in an up-flow or down-flow mode.
- The filter can be mono or multimedia and they are cleansed by backwashing.
- The filtration rate may range between (10000-20000 lts/ hr per m²).
- These types of Filter are mostly used in connection with iron removal plants in municipal towns.
- The Pressure Filters are widely used in industries.

C. **Water Softening**

Water Softening is the removal of certain dissolved minerals in water that cause scaling in boilers, form deposits on pipes and cause excessive consumption of soaps. Hardness in water is mostly due to presence of cations such as calcium and magnesium (di-valent cations)

I. **Boiling**

- Boiling removes carbonate or temporary hardness caused due to presence of bicarbonates in water.
- This is a household process for partial softening of hard water.

II. Lime Soda Softening

- Lime and Soda ash in requisite proportion are added for water softening.
- By this treatment calcium and magnesium concentration can be brought down approximately to 30 mg/l as CaCO_3 and 10 mg/l as MgCO_3 respectively.
- The process has limited applications.

III. Ion Exchange

- The process of water softening i.e., reduction of hardness can be carried out by exchanging the undesirable Calcium and Magnesium cations with Sodium.
- Normally water softening units consist of a bed of the medium of about 0.5 to 2 meter high with a filtration rate of about $14.4 \text{ m}^3/\text{hr per m}^2$.
- The process of Softening does not remove all the hardness.
- This process is widely used for softening of ground water in industries as well as in-housing societies.

D. Membrane Process

Membrane treatment process is used to separate dissolved and collided constituents from water. In Membrane treatment, water or components in water are driven through membrane under the driving force of a pressure, electrical potential or concentration gradient. Membrane treatment is used for filtration, removal of micro – organism, hardness, volatile organics and other soluble organics. Membrane Separation techniques include:-

- Micro Filtration (MF)
- Ultra Filtration (UF)/ Nano Filtration (NF)
- Reverse Osmosis (RO)
- Electrodialysis (ED)

Schematic of the Particle sizes and associated separation techniques are presented below:-

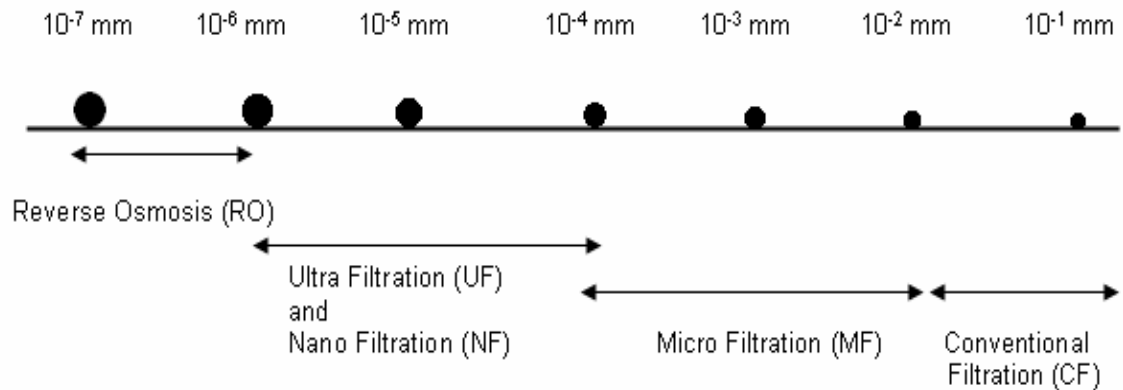


Figure -1: Separation Process and Associated Particle Sizes

i) Micro Filtration

- Micro Filtration allows macro molecules (10^{-4} mm to 10^{-3} mm) to flow through the membrane.
- Bacteria that are larger than 10^{-4} mm are prevented from passing through the membrane wall.
- The wall pores in these units are 10^{-3} mm to 10^{-2} mm.
- Micro filtration is a physical process marketed in a ready to use cartridge or modular housing that can remove particles between 0.05 and 5 μm (micro-metre) in size.
- The membrane come in a variety of forms, such as tabular, capillary, hollow fibre and spirally wound sheets.

ii) Ultra Filtration

- Ultra Filtration is similar to Micro Filtration except membrane micropores are much smaller and the pressure required to force the untreated water through is much greater.
- Widely used polymers for Ultra Filtration membranes include polysulphone polyacrylonitrile, polyimide and cellulose acetate. Inorganic ceramic membranes are also used for certain industrial process.
- Owing to the small particles removed (0.001 – 0.02 μm) UF has different applications to MF with solvents and salts of low molecular weight able to pass through the membrane while larger molecules are retained.

iii) **Reverse Osmosis**

- Reverse Osmosis (RO) uses a semi-permeable membrane that unlike MF and UF membranes does not have pores.
- This is a solubilization diffusion technique that makes use of a semi-permeable membrane which acts as a barrier to dissolved salts and inorganic molecules.
- RO technique is considerably used in desalination. It has application for removal of excess dissolved solids in water treatment for housing societies. RO membranes are able to remove ions such as sodium and chloride in addition to calcium, magnesium and other ions. Arsenic and excess fluoride can also be removed by RO methods.
- RO generates rejects which depends on concentration of dissolved solids, salinity, membrane characteristics etc.

iv) **Nano Filtration**

- Nano Filtration is similar to RO and is pressure driven processes that employ membranes that are capable of both physical sieving and diffusion – controlled transport.
- It is possible due to the recent development of thin film non-cellulose membrane.
- Compared to RO, Nano Filtration systems operate at much lower pressures but yield higher flow rates of permeate.
- The particle size removal range for Nano Filtration is 0.0005 – 0.005 μm . The process removes calcium and magnesium ions, color, total organic carbon (TOC), humic acids and organic molecules.

E. Adsorption

Adsorption is a physical process where soluble molecules (adsorbate) are removed by attachment to the surface of a solid substrate (adsorbent) primarily by Van der Waals forces, although chemical or electrical attraction may also be important. Adsorbents must have a very high specific surface area and include activated alumina, activated carbon, clay colloids, hydroxides and adsorbent resins. Activated carbon is widely used for water treatment.

i) **Powdered Activated Carbon (PAC)**

- In water treatment, powdered activated carbon is added at the rapid mixing stage of chemical coagulation or immediately prior to sand filtration.
- The application of PAC in water treatment is limited.

ii) **Granular Activated Carbon or Activated Carbon Filter**

- Granular Activated Carbon is easier to handle than Powdered Activated Carbon and is used for continuous application in either a packed or expanded bed.
- GAC is used as media for filtration whereby water particles come in contact with GAC and the contaminants are absorbed by the carbon. The removals of contaminants are dependent on contact time and accordingly the filtration rates are adjusted.
- The activated carbon has limited capacity of adsorbate adsorption. The GAC can be regulated for further use.
- GAC has wide application in the development of domestic water filter. GAC is also extensively used in industrial water and waste water treatment. It is commonly called Activated Carbon Filter (ACF).

iii) **Activated Alumina**

- Activated alumina has property of adsorption of specific dissolved solids.
- Activated Alumina as adsorbent is used for removal of excess fluoride and arsenic from ground water. Community water treatment unit, hand pumps attached unit and domestic Filter have been developed using activated alumina.
- Activated alumina can also be regenerated.

F. **Ion Exchange**

- Ion Exchange is an adsorption process that employs the reversible interchange of ions of the same charge between a solid ion exchange medium and a solution.
- Used primarily for water softening. Ca_2^+ and Mg_2^+ cations are exchanged by Na^+ where Na_2R is the ion exchange medium with R the negatively charged polymer.
- Most exchange media are synthetic polymer resins, although naturally occurring zeolites which are Sodium-alumino-silicates are also used.
- While water softening remains the largest application of ion exchange, the process is also used to remove cations such as arsenic, chromium, barium, strontium and radium and anions such as nitrate, fluoride, cyanide.
- Different resins have a different order of affinity based on the relative concentrations of the ions.

G. Disinfection

Disinfection is the destruction of pathogenic micro organism in water. The eradication of water borne pathogens is the most important treatment of water. Following methods are applicable for disinfection of water to make it pathogen-free.

i) Boiling

- Boiling for 10 minutes eradicates pathogenic organism but it is too energy intensive to be used for water disinfection.
- It is only applicable at domestic level when users are convinced
- Dependable method to make water pathogen-free

ii) Chlorination

- Chlorine when added in water form hypochlorous acid (HOCl) and hypochlorite ions (OCl^-).
- Both HOCl and OCl^- kill pathogens.
- Disinfection by chlorination is pH dependent.
- In conventional urban water treatment plant liquid chlorine is used for disinfection. In small water treatment units bleaching powder, sodium hypochlorite and calcium hypochlorite are used.
- Chlorine has residual effect in water and that helps to keep pipe lines free from post contamination.
- Residual chlorine should not be more than 0.2 mg/l at consumer end
- In public water supply only chlorination is used for disinfection of water

iii) Ozonisation

- Ozone is a powerful oxidising agent and a very effective biocide
- It is not used for municipal water treatment plants in India.
- It is used in package plants.
- Most of the package drinking water manufacturers in India use ozonisation for disinfection of water.

iv) **UV – RAY**

- Ultra violet radiation which is electromagnetic radiation in the shorter wavelength range causes die-off of micro-organism and leaves no residual radiation. Thus no residual power remains in water for disinfection.
- It is used in domestic water purifier for disinfection
- This process is used by the package drinking water manufacturers for disinfection of water
- In public water supply UV-radiation is not utilized in India.

v) **Solar Disinfection (SODIS)**

- Sunlight is a natural alternative to synthetic disinfection.
- Ultra violet radiation is a component of solar radiation.
- Shorter wavelengths solar radiation (between 5 and 400 nanometer) have higher germicidal effect
- The process can be utilized at domestic level and institutional level for disinfection of water.

vi) **Silver**

- Silver has been used in limited circumstances for disinfection since silver has bactericidal power.
- Silver impregnated filter candle removes pathogens from water.

1.6 GENERAL EFFECTIVENESS OF VARIOUS WATER TREATMENT TECHNOLOGIES

The contaminants as well as undesirable substances could be removed by adopting appropriate unit operations in water treatment processes. General effectiveness of different water treatment processes and undesirable substances removal are presented in **Table No. 1.1**

1.7 OVERVIEW OF CONTAMINANTS / SUBSTANCES REMOVAL TECHNOLOGY- WISE

Each of the technologies has strengths for separation of particular contaminants / substances from water. Accordingly the particular technology is considered as Excellent for removal of corresponding particular contaminants / substances from water. **Table No 1.2**, therefore, highlights the different technologies which separates contaminants / substances from the water to the tune of 90-100% (Excellent). This table also gives the over all details of Number of Manufacturers Technology –wise, Capacity of the System, Market Readiness of a Particular Technology, Power Needs, Operational Parameters like Purification Cost, Operation & Maintenance Cost and Wastage of Water in the System.

1.8 TIME PERIOD

The study was completed in 12 months' time.

1.9 LIMITATIONS

- In the report analysis has been carried out technology / system wise. Performance of any individual brand or any individual organization is not within the scope of this study.
- Following technologies / systems do not deal with drinking water purification and, therefore, have not been included in the report:-
 - Trickling Filter
 - Hydro Pneumatic System
 - Magnetic Conditioning System
- No separate validation of data was possible by NAFEN. Report has been prepared based on the data collected/ received from the respondents.
- Utmost care, which is humanly possible, has been taken to ensure that the data analysis is correct.

1.10 REFERENCES

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- Prof. (Dr.) Arunabha Majumder, Resources Conservation and Preventive and Remedial Measures in Drinking Water Supply

Table No.: 1.1

General Effectiveness of Water Treatment Processes for Contaminants / Substances Removal

Sr. No.	Contaminants	Aeration and Stripping	Coagulation + Flocculation + Sedimentation + Filtration	Softening (Lime + Soda)	Ion Exchange		Membrane Process			Chemical Oxidation, Disinfection	Adsorption			Package HH Unit (Filtration+ Adsorption + UV Ray)
					Anion	Cation	Reverse Osmosis	Nano Filtration	Ultra Filtration		GAC (Carbon Filter)	PAC	Activated Alumina	
1 (i)	Taste and Odour	F – E	P – F	P – F	--	--	--	--	--	F – E	G – E	G – E	P – F	E
(ii)	Color	P	F – G	F – G	P – G	--	--	--	--	F – E	E	G – E	G	E
2	TDS	P	P	P – F	G – E	F	G – E	F – G	P – F	P	P	P	P	--
3	Turbidity	P	E	G	P	P	E	E	E	P	F	P	G – E	E
4	Chloride	P	P	P	F – G	P	G – E	P – F	P	P	P	P	--	--
5	Hardness	P	P	E	P	E	E	G – E	G – E	P	P	P	P	P
6 (i)	Iron	F – G	F – E	E	P	G – E	G – E	G	G	G – E	P – F	P	P	E
(ii)	Manganese	P – F	F – E	E	P	G – E	G – E	G	G	F – E	P	P	P	E
7	Sulphate	P	P	P	G – E	P	E	P – F	P	P	P	P	F – G	--
8	Arsenic	P	F – G	F – G	G – E	P	F – E	P	--	P	P	P	G – E	P
9	Fluoride	P	F – G	P – F	P – F	P	E	P	--	P	F – G	P	E	--
10	Nitrate	P	P	P	G – E	P	G	P	--	P	P	P	P	--
11	Cadmium	P	G – E	E	P	E	E	P	--	P	P – F	P	P	--
12	Chromium	P	G – E	G – E	P	E	G – E	P	--	P	F – G	F	P	--
13	Lead	P	E	E	P	F – G	E	P	--	P	F – G	P – F	P	--
14	Nickel	P	F – G	E	P	E	E	P	--	P	F – G	P – F	P	--
15	VOCs	G – E	P	P – F	P	P	F – E	F – E	F – E	P – G	F – E	P – G	P	G
16	Pesticides	P – F	P – G	P – F	P	P	F – E	F – E	F – E	P – G	G – E	G – E	P – G	G
17	Total Coli form	P	G – E	G – E	P	P	E	E	E	E	F	P	P	E
18	Faecel Coli form	P	G – E	G – E	P	P	E	E	E	E	F	P	P	E

Legend:-

P (Poor) = 0-20% removal

E (Excellent) = 90-100% removal

PAC = Powdered Activated Carbon

F (Fair) = 20-60% removal

-- = NA (Not Applicable)

VOCs = Volatile Organic Carbon

G (Good) = 60-90% removal

GAC = Granular Activated Carbon

HH = Household

Table No.: 1.2
Overview of Contaminants / Substances Removal Technology-wise

Technology → ↓ Parameters	Filtration + Adsorption + UV Ray	Candle Filter (Ordinary)	Candle Filter (Silver Impregnated)	Ion-Exchange (Water Softening & Demineralization)	Aeration+ Sedimentation (Optional) + Pressure Filtration (Iron Removal Filter)	Reverse Osmosis (Desalination)	Ultra Filtration (Micron Filter)	Carbon Filter	Activated Alumina Filter	Chlorine Tablet & Solution (Chlorination)	Ozonisation	UV - RAY
Number of Manufacturers	NR	40	NR	57	109	115	22	189	NR	42	21	86
Capacity of the System (lph)	NR	<15-<500	NR	>15-<500	>15-<500	<15->5000	<15-<500	<15	NR	<15->5000	Not used in House Hold Systems	<15-<500
Contaminants / Substances Removed	Color, Taste & Odor, Turbidity, Iron, Total Coliform, Faecal Coliform	Turbidity, Iron, Total Coliform, Faecal Coliform	Turbidity, Iron, Total Coliform, Faecal Coliform	Arsenic, Iron, Nitrate, Sulphate, TDS	Color Taste & Odor, Turbidity, Iron,	Turbidity, Arsenic, Chloride, Fluoride, Iron, Nitrate, Sulphate, TDS, Total Coliform, Faecal Coliform	Turbidity, Iron, Total Coliform, Faecal Coliform	Color Taste & Odor, Fluoride	Color, Turbidity, Arsenic, Fluoride, Sulphate	Total Coliform, Faecal Coliform	Total Coliform, Faecal Coliform	Total Coliform, Faecal Coliform
Commerlization Status (Market Readiness)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Power Needs	NR	No	NR	Yes	Yes	Yes	Yes/No	No/Yes	NR	Yes	Yes	Yes
Purification Cost (Rs. Kl)	44-50	8-11	9-12	50-60	15-25	70-90	60-70	17-20	15-20	1-2	NR	22-25
Operations & Maintenance Cost Rs./KL	50-60	8-12	12-20	40-50	25-35	60-70	50-60	16-20	12-20	1-2	NR	22-25
Wastage of Water %	3-5	3-5	3-5	3-6	3-5	30-50	30-50	2-3	4-5	1-2	NR	1-2

Note: NR---Not Reported

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