DRINKING WATER ISSUES IN PAKISTAN

INITIAL DRAFT

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"A fundamental promise we must make to our people is that the water they drink is safe."

Haroon

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ABBREVIATIONS USED

Abbreviation	Description
EPA	Environmental Protection Agency
GI	Gastrointestinal
GoP	Government of Pakistan
MoST	Ministry of Science and Technology
MPL	Maximum Permissible Level
PIHS	Pakistan Integrated Household Survey

EXECUTIVE SUMMARY

Access to adequate water of acceptable quality is fundamental for all living beings. The provision of potable water for the world population is increasingly becoming a problem for the entire world, developing countries being no exception. Pakistan is a semi arid region, and like the rest of the world, clean water sources are rapidly depleting. This not only poses the problem of the access of essentially required water, but also forces the population to drink, low quality water which is hazardous to health. Such a grave health situation effects all of us, the consumers, whose life depends upon water. Already many million deaths have been attributed to drinking unclean water. Measures should therefore be taken to ensure availability of clean potable, drinking water for communities. Enforcement regarding quality public service provision comes foremost. Standards set for quality of such water, should be realistic, and should take into account the current situation in Pakistan.

The Network, working for consumer protection in Pakistan feels that safe drinking water is not only the right of everybody, in Pakistan, it will also go a long way in alleviating the misery of the burden of disease being shared by water-related illnesses. The need is also felt that instead of scattering the work on water quality in various departments, the Government should take concrete steps in holding a body responsible for tackling the whole issue of water. Trained staff should be brought in, to ensure adequate water treatment before it is supplied to the consumers, and at water testing facilities, whatever few are available. Already present staff should be imparted on-the-job trainings to help them improve their working. Protection of sources of water supply should be made mandatory, whether it be a public water supply or a domestic level private water supply. At the same time the community's awareness needs to be enhanced regarding the whole water problem, so that they can prevent themselves from the ill-effects of drinking unclean water, and also rise to the occasion, and voice their concern at the right forum.

This document has been drafted in the spirit that it will help to become a guiding road-map for the experts who claim to know so much, and are doing so little; that it will help the activists, who want to do a lot, but have no clear vision of how to proceed; and that ordinary ilk, who know so little, and yet are the ones who are the most affected.

1. INTRODUCTION

Water is an essential nutrient, necessary for maintaining body temperature, transporting nutrients throughout the body, keeping joints moist, food digestion, ridding the body of waste products, and cooling the body. It is recommended by the American Health Association that an adult should consume approximately 3 Liters of water each day; children about half as much. While the best way to consume this amount is by drinking plain water, foods and beverages made with water also count as part of this amount.

1.1 Chemical Properties of Water:

The Hydrogen atoms are "attached" to one side of the Oxygen atom, resulting in a water molecule having a positive charge on the side where the hydrogen atoms are and a negative charge on the other side, where the oxygen atom is. Since opposite electrical charges attract, water molecules tend to attract each other, making water kind of "sticky."

All these water molecules attracting each other mean they tend to clump together. This is why water drops are, in fact, drops! If it wasn't for some of Earth's forces, such as gravity, a drop of water would be ball shaped -- a perfect sphere.

Water is called the "universal solvent" because it dissolves more substances than any other liquid. This means that wherever water goes, either through the ground or through our bodies, it takes along valuable chemicals, minerals, and nutrients.

Pure water has a neutral pH. Pure water has a pH, of about 7, which is neither acidic nor basic.

1.2 Water's Physical Properties

1.2.1 States of Water

Water is unique in that it is the only natural substance that is found in all three states -- liquid, solid (ice), and gas (steam) -- at the temperatures normally found on Earth. Earth's water is constantly interacting, changing, and in movement

1.2.2 Water Temperatures

Water freezes at 32 degree Fahrenheit (F) and boils at 212 degree F (at sea level, but 186.4° at 14,000 feet). In fact, water's freezing and boiling points are the baseline with which temperature is measured: 0 degree on the Celsius scale is water's freezing point, and 100 degrees is water's boiling point. Water is unusual in that the solid form, ice, is less dense than the liquid form, which is why ice floats.

1.2.2.1 Factors influencing water temperature:

(i) Soil erosion can increase the amount of suspended solids in the water. As a result, the turbid water's particles absorb the sun's rays, which cause the water temperature to increase.

(ii) The depth of the watershed allows deeper waters to remain cooler than compared to shallow waters.
(iii) Cooler water temperatures are expected in the evening and warmer temperatures are expected during the day when the sun is out.
(iv) The reduction of water flow near operating dams may increase water temperature.
(v) The air temperature which change seasonally. Water temperatures can range from 0 degrees Celsius in the winter to 30 degrees Celsius in the summer.
(vi) Thermal pollution may cause a the temperature to increase by adding warm water. Industries such as nuclear power plants may cause thermal pollution by releasing water used to cool machinery. Thermal pollution may also be caused by rain water running off warm urban surfaces, such as streets, sidewalks, and parking lots.

1.2.3 Specific Heat

Water has a high specific heat index. This means that water can absorb a lot of heat before it begins to get hot. This is why water is valuable to industries and as an automobile coolant. The high specific heat index of water also helps regulate the rate at which air changes temperature, which is why the temperature change between seasons is gradual rather than sudden, especially near the oceans.

1.2.4 Surface Tension

Water has a very high surface tension. In other words, water is sticky and elastic, and tends to clump together in drops rather than spread out in a thin film. Surface tension is responsible for capillary action, which allows water (and its dissolved substances) to move through the roots of plants and through the tiny blood vessels in our bodies.

1.2.5 Alkalinity

It is the measure of the capacity of water to neutralize acids or hydrogen ions. Alkalinity is sometimes referred to as "carbonate hardness".

1.2.5.1 Factors influencing the amount of alkalinity:

(i) Alkalinity may be due to the presence of the bicarbonate ion, which is derived from the dissolution of carbonates by carbonic acids.
(ii) Minor contributors to alkalinity include carbonate and hydroxide ions.
(iii) Some sources of alkalinity are leached from limestone and soil.
(iv) Some minerals such as dolomite and calcite provide a source of alkalinity.
(v) Low alkalinity may be due to high levels of precipitation in the form of rain or snow.

1.2.6 Turbidity

It is the measurement of lack of water clarity that is measured in NTU or JTU.

1.2.6.1 Factors influencing the amount of turbidity:

(i) Turbidity is the result of suspended solids in the water that range from clay and silt, to industrial wastes and sewage. The lower the turbidity, the clearer the water is.
(ii) High turbidity may be caused by soil erosion, waste discharge, urban runoff, flooding, dredging operations, increased flow rates or algal growth.

1.2.7 Total Dissolved Solids

The total dissolved solids test measures the amount of particles that are dissolved in the water. It may include all suspended solids that may or may not pass through a filter.

1.2.7.1 Factors influencing the amount of total dissolved solids:

(i) Some dissolved solids come from organic sources such as leaves, silt, and industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street during the winter, and fertilizers and pesticides used on lawns and farms.
(ii) Some dissolved solids come from inorganic materials such as rocks and air that may contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur, and other minerals. Many of these materials form salts, which are compounds that contain both a metal and a nonmetal. Salts usually dissolve in water forming ions, which have a positive or negative charge.

1.2.8 pH

It is a general measurement of the acidity or alkalinity of a water sample. The symbol pH stands for the "potential for hydrogen".

1.2.8.1 Factors affecting pH of water:

(i) Rainwater provides a significant amount of water. Acid rain is caused by increased amount of nitrogen oxides and sulfur dioxides automobile and coal-fired power plant emissions. Nitrogen oxides and sulfur dioxides are changed to nitric acid and sulfuric acid when they interact with water in the atmosphere. These acids combine with moisture in the air and fall to the earth as acid rain or snow. Consequently, the pH of rain influences the overall pH of the water in a reservoir.

(ii) The kind of rocks or soil around a water reservior over which runoff passes can also affect the overall pH. If limestone is present, the alkaline rocks may neutralize the acidic water.

(iii) Algal blooms may cause the water's pH to become more basic.

(iv) As aquatic plants decompose, they release carbonic acid into the water.

1.2.9 Phosphates

Phosphates are chemical compounds made from the elements phosphorous and oxygen. Phosphorous is usually present in water in the form of phosphate.

1.2.9.1 Factors affecting phosphates in water:

(i) Phosphates are usually present in the environment in low concentrations, which limits plant growth. High phosphate levels can come from man-made sources such as septic systems, fertilizer runoff and improperly treated waste-water. The phosphates enter the water as the result of surface run-off and bank erosion.

(ii) Many detergents contained phosphates before manufacturers developed phosphate-free alternatives.

(iii) An increase in nitrate levels may cause an increase in phosphate levels.

1.2.10 Dissolved Oxygen

Dissolved oxygen is the measurement of the amount of oxygen freely available in water.

1.2.10.1 Factors influencing the amount of dissolved oxygen in water:

(i) Temperature has a big effect on amount of dissolved oxygen water can hold. Warmer water can hold less dissolved oxygen than colder water. Consequently, this may also vary depending on the season, weather, the time of day, and the amount of thermal pollution.

(ii) When there is an overabundance of organic matter like dead algae, aquatic aerobic bacteria can grow rapidly. These bacteria consume oxygen during respiration and as a result, the amount of dissolved oxygen in the water is decreased.

(iii) Low atmospheric pressure found at higher altitudes slightly decreases the solubility of dissolved oxygen.

(iv) The various minerals dissolved in water can lower the water's capacity to hold oxygen. Consequently, a lower salinity equals a higher potential for dissolved oxygen concentration.

(v) Mixing of air and water caused by swiftly flowing water over rocks, by wind, or thermal upwelling, increases dissolved oxygen concentrations. This process is called aeration. A body of water that is very stagnant may result in very low dissolved oxygen concentration.

1.2.11 Chloride and Salinity

Chloride (Cl-) is one of the major inorganic anions, or negative ions, in saltwater and freshwater. It originates from the dissociation of salts, such as sodium chloride or calcium chloride, in water. Chlorides are binary compounds of chlorine. Chlorine chemically combines with a metal to from chloride.

Salinity is the total of all non-carbonate salts dissolved in water. This is comprised mostly by Cl- and Na+ ions. Seawater may have other ions, such as K+, Mg2+, or SO42-.

1.2.11.1 Factors influencing the amount of chloride and salinity in water:

(i) When hydrochloric acid reacts with any metal in water, chloride is naturally formed.
(ii) Chloride is common in areas with limestone deposits, but is not found in most other soils, rocks, or minerals.
(iii) Water pollution may be the cause of chloride found in areas where it does not naturally occur. Some sources may be from rock salt (NaCl) runoff. Other sources may be from septic tank effluent, animal waste, water softener regeneration, chlorinated drinking water, and potash fertilizer (KCl).
(iv) Sources of chloride ions may come from the mixing of seawater with fresh water.

1.2.12 Calcium and Water Hardness

Water hardness is the state or quality of being hard caused by various dissolved salts of calcium, magnesium, or iron.

Calcium (Ca2+) is one of the major inorganic cations, or positive ions, in saltwater and freshwater. It originates from the dissociation of salts, such as calcium chloride or calcium sulfate, in water.

1.2.12.1 Factors influencing the amount of calcium in water:

(i) Various dissolved salts of calcium, magnesium, or iron in the river cause water hardness.
(ii) Calcium and magnesium enter the water mainly by leaching of rocks. Most calcium in surface waters comes from streams flowing over limestone, dolomite, gypsum, and other calcium-containing rocks and minerals.

1.2.13 Ammonium Nitrogen

The ammonium ion, $NH4+$, is an important member of the group of nitrogen-containing compounds that act as nutrients for aquatic plants and algae. In surface water, most of the ammonia, NH3, is found in the form of ammonium ion, NH4+. This fact allows us to approximate the concentration of all of the nitrogen in the form of ammonia and ammonium combined, commonly called ammonia nitrogen, be measuring the concentration of the ammonium ions.

1.2.13.1 Factors influencing the amount of ammonium nitrogen in water:

(i) Decaying plants and animals.
(ii) Animal waste
(iii) Industrial waste effluent
(iv) Agricultural runoff
(v) Atmospheric nitrogen

2. SOURCES / QUANTITY OF WATER

The earth contains 326,000,000 cubic miles of water, and over 70% of the earth's surface is covered by water. *(US Geological Survey)*

Only about 0.25% of the water on earth is available for drinking, agriculture, or industry.

Nearly 99.75% of the water on earth is either salty (mostly in the oceans) or locked up as ice (mostly in the polar ice caps). The majority of the fresh water (87%) is locked away as ice in the polar ice caps, continental ice sheets and glaciers

Fresh, water accounts for only about 2% of the world's total water supply, the rest is salt water. (see Fig.1)

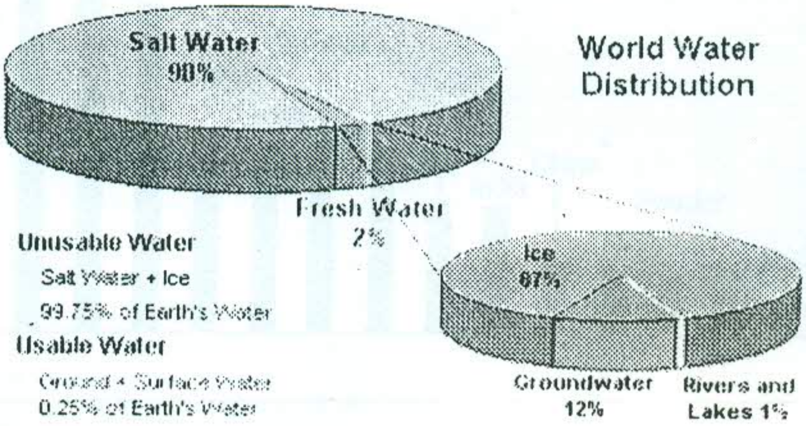


Fig.1 : Shows Global Total Water and Fresh Water Reserves
Coutesy : pakistanwater.8m.net

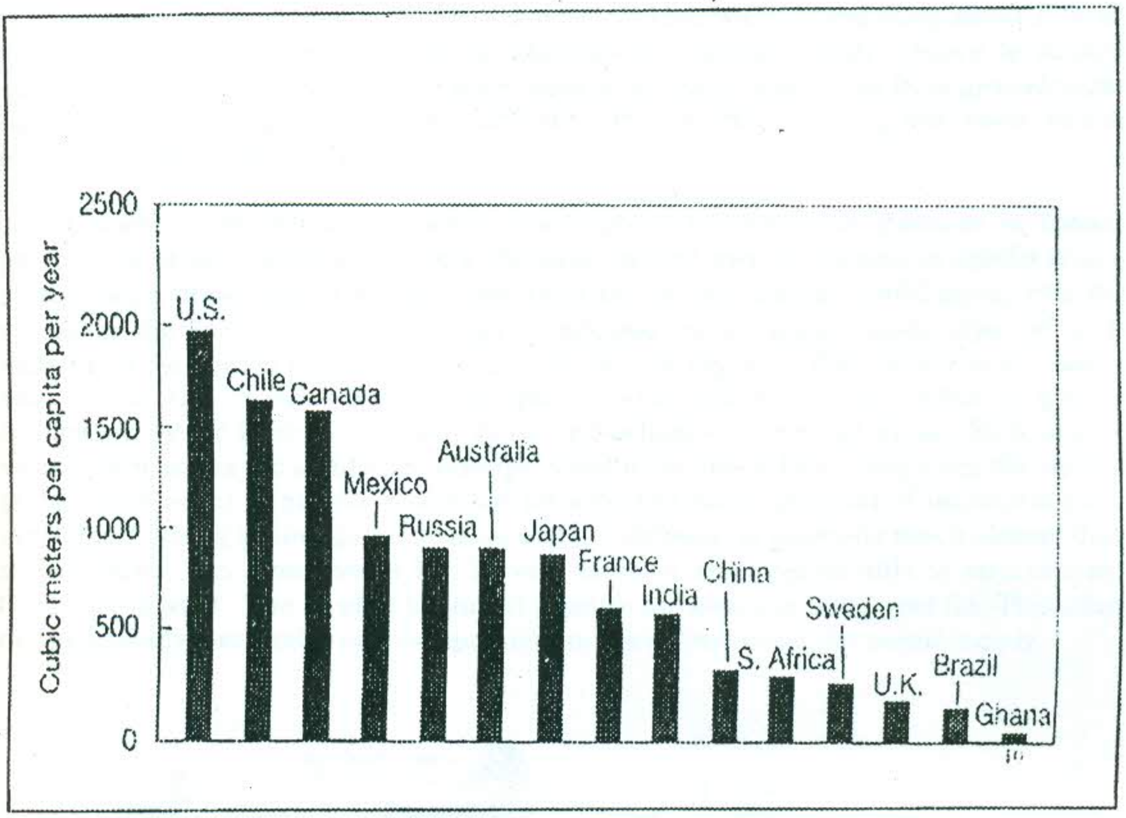


Fig. 2 : Water Withdarwn Per Capita in Selected Countries
Courtesy : Dr. Saqib Shahab, Health Services Academy, Islamabad

There are only two sources of fresh water for all individuals in the world

- Surface water (such as rivers and lakes, only accounts for less than 1% of the worlds fresh water reserves); and
- Ground Water (about 12% is groundwater)

2.1 Surface water:

Even though fresh surface water (in rivers, streams, lakes, and reservoirs) makes up just 1% of the fresh water in the world, about 75% of all the water we use in everyday life come from surface water sources. The other 25% comes from ground water. It is only natural that we heavily use our surface water resources. It is a lot easier and cheaper to get water out of a river, lake, or reservoir than it is to drill a well and pump water out of the ground. Unfortunately, however, the accessibility of surface water makes them very easy to pollute. Until fairly recently the obvious solution to removing noxious wastes from a person's immediate environment was to dump it into the nearest river and watch it drift out of the "neighborhood".

2.2 Ground water:

Ground water is the largest available reservoir of fresh water, comprising about 12% of the available fresh water. Despite the abundance of ground water relative to surface water, only about 25 % of the fresh water used in everyday life comes from ground water aquifers. This is largely due to the difficulty and expense of using this water source relative to surface water.

Groundwater is defined as the water filling spaces between rock particles in special porous rock layers known as 'aquifers'. Perhaps the best way of imaging an aquifer is as a solid sponge. Rainwater trickling down from the ground surface (infiltration) fills the spaces in the rock. When the water is stopped by an impermeable layer of rock underneath the aquifer (a confining layer), the aquifer begins to fill. Water in an aquifer does not sit still. It flows through the spaces and cracks in the rock, pulled by gravity and pushed by the force of the water above and behind it. The water moves from an area where water enters the aquifer (a recharge zone) to an area where water exits the aquifer (a discharge zone). This movement has the effect of removing a lot of impurities from the water, filtering it through the rock so that groundwater is generally much cleaner than surface water. As groundwater can be very clean, it may require little or no treatment before being used. The level of treatment depends on what it is to be used for. This often makes groundwater a relatively inexpensive source of 'raw water' for public supply.

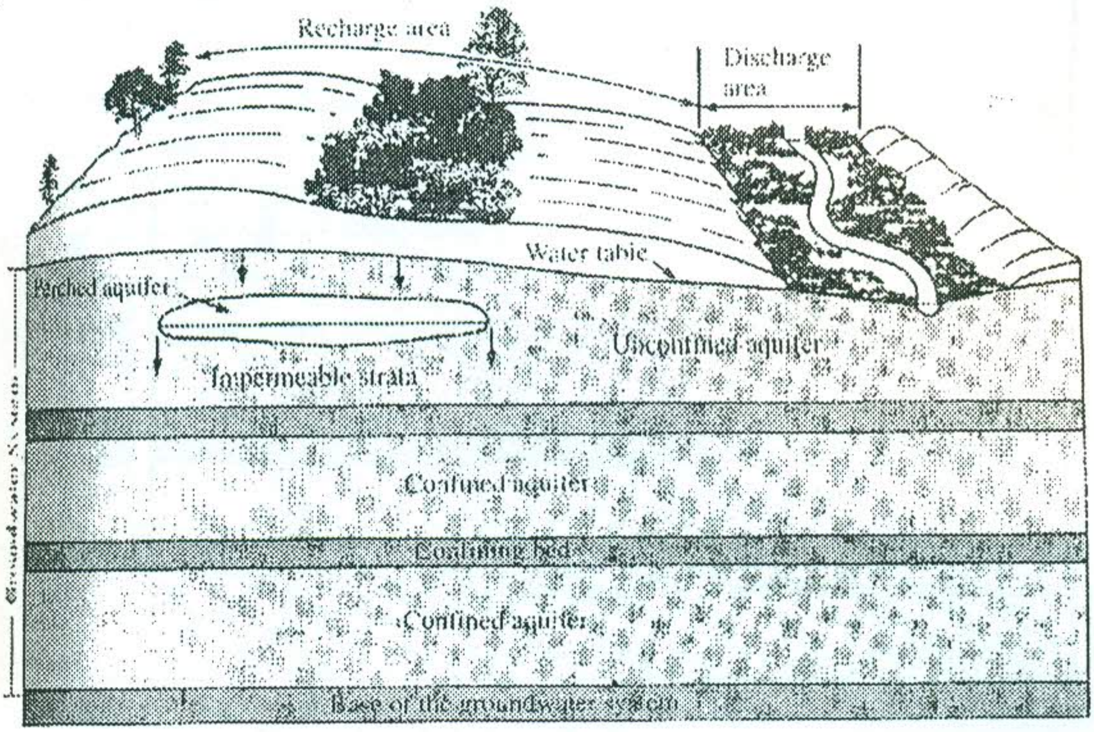


Fig. 3 : Groundwater Systems
Courtesy: Water Supply and Pollution Control, Viessman Jr., 1992

2.3 The Water Cycle:

Fortunately, Earth's water supply is not static - we don't just use up the fresh water and then run out. The fresh water supply is constantly purified and replenished (although human activity can negatively impact this process). The overall water distribution on earth is in balance in the following manner:

- Evaporating from lakes, streams, rivers, oceans, land surfaces, plants, animals, and ice fields
- Circulating in the atmosphere as water vapor
- Condensing and falling back to the surface as precipitation, rain, snow, hail, etc.
- Flowing through the soil to recharge groundwater aquifers
- Flowing out of groundwater aquifers into rivers and lakes
- Flowing along the surface back to the oceans

When water evaporates it leaves most of the contaminants behind. The relatively pure water vapor can then pick up vaporous or particulate pollutants from the atmosphere as it precipitates. After falling on the Earth's surface, the water can dissolve more pollutants from the soil or rocks it comes in contact with.

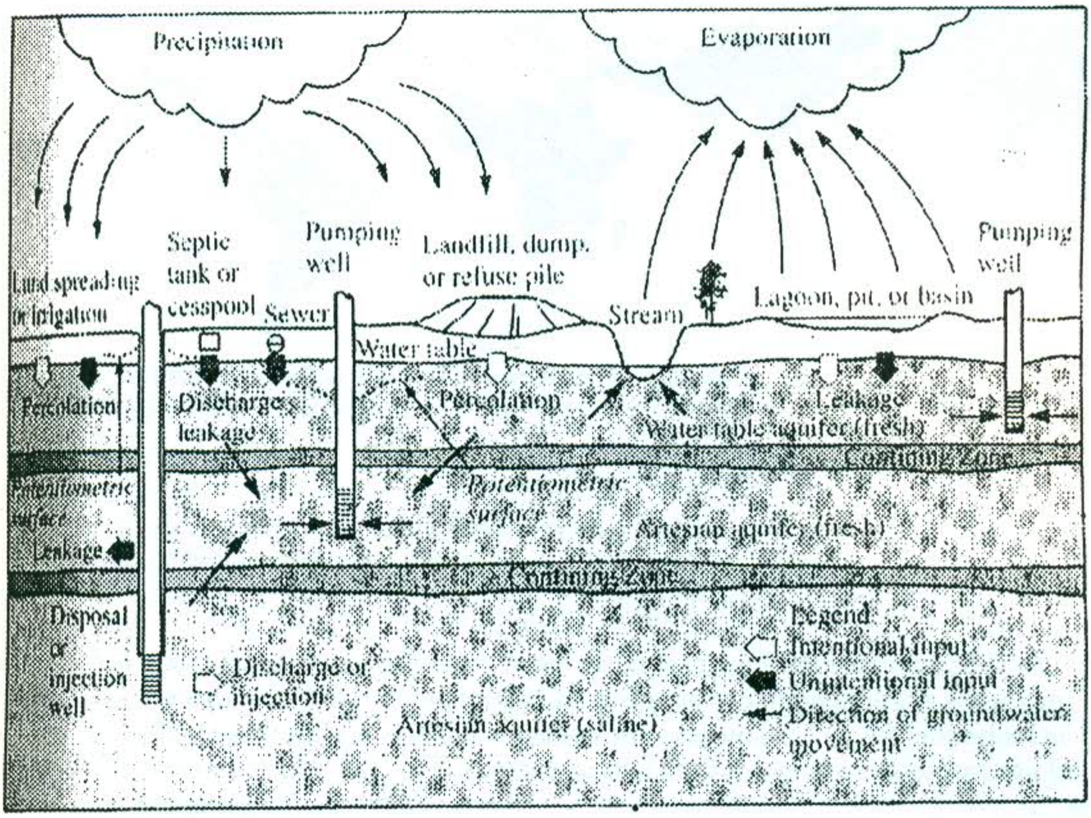


Fig. 4: The Hydrologic Cycle
Courtesy: Water Supply and Pollution Control, Viessman Jr., 1992

3. ACCESS

A clean, constant supply of drinking water is essential to every community. People in large cities frequently drink water that comes from surface water sources, such as lakes, rivers, and reservoirs. Sometimes these sources are close to the community. Other times, drinking water suppliers get their water from sources many miles away. In either case, it's important to consider not just the part of the river or lake that supplies the water, but the entire watershed. The watershed is the land area over which water flows into the river, lake, or reservoir. In rural areas, people are more likely to drink ground water that was pumped from a well. These wells tap into aquifers--the natural reservoirs under the earth's surface--that may be only a few miles wide, or may span the borders of many states. As with surface water, it is important to remember that activities many miles away may affect the quality of ground water.[1]

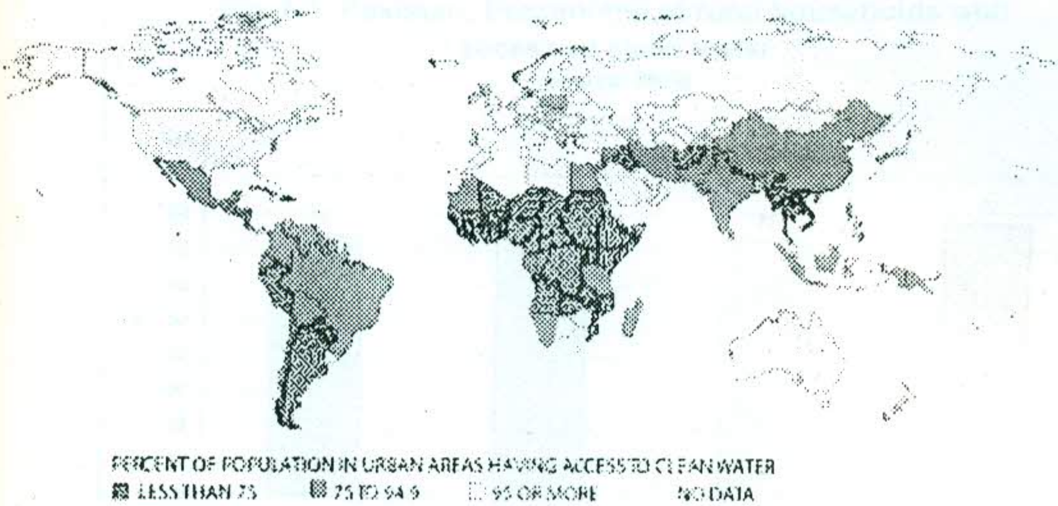


Fig. 5: Accessibility to clean drinking water (global)
Courtesy: Scientific American Issue 1197

Sediment can affect the delivery of water. When water is taken from streams and lakes for domestic, industrial, and agricultural uses, the presence of sediment in the water can wear out the pumps and turbines. As this increases maintenance costs, it is important to determine the amount of sediment in the stream so that the appropriate equipment can be chosen when designing a water supply plant.

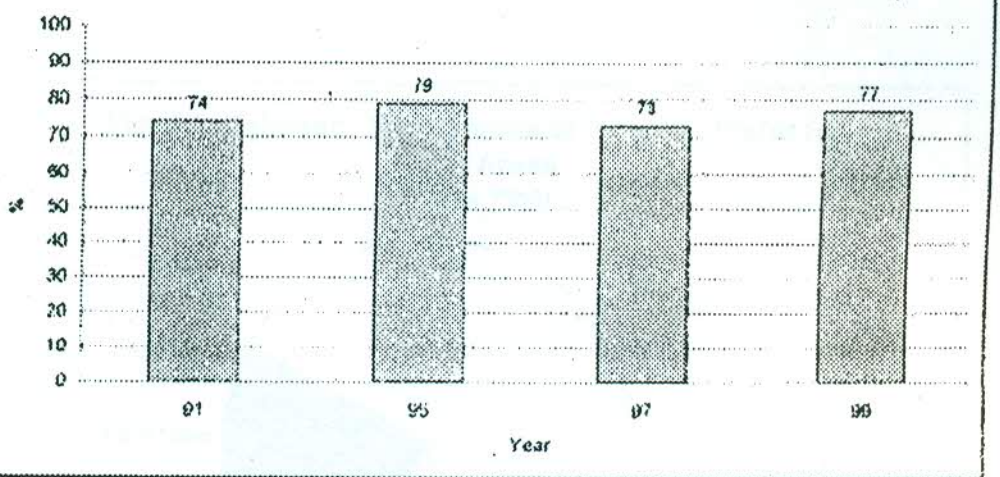
[1] Where does drinking water come from: Ground and Drinking water. USEPA Office of Water, Jan'02

3.1 Access to Clean Drinking Water in Pakistan

According to the Pakistan Integrated Household Survey (PIHS), the percentage of rural households having access to clean water, either piped water through a tap, or hand pump, or motorized pump, was 74% in the year 1990-91. This increased to 77% in the year 1998-99. This increase has been attributed to increase in the number of hand pumps installed.

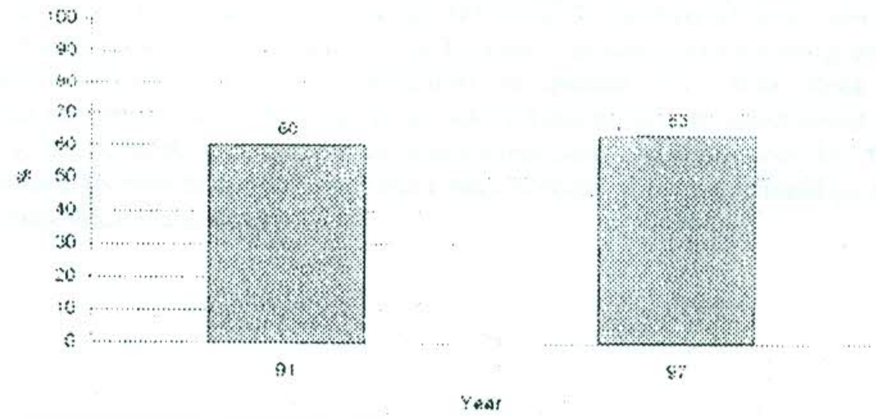
If the water source is outside the compound of a house, it may be shared. A limited number of hand pumps shared between a village, for example, may reduce availability, flow and cleanliness, and will usually be further form the household, requiring more time to access the water. This is less convenient and there is evidence that it reduces the volume of water used in the household, with a negative effect on health. (Fig.5.1, 5.2, 5.3)

Fig. 5.1. Pakistan: Percentage of rural households with access to clean water
(Source: PIHS)



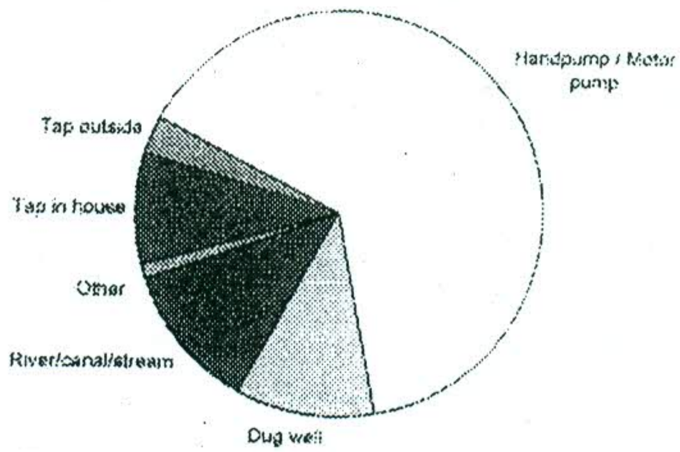
Source : PIHS, 1991-99

Fig. 5.2. Pakistan: Percentage of Rural Households with a Safe and Convenient Water Source
(Source: PIHS)



Source : PIHS, 1991-99

Fig. 5.3. Pakistan: Main Source of Drinking Water for Rural Areas
(Source: PIHS)



Source : PIHS, 1991-99

3.2 Accessibility Patterns

We use tap water for various purposes. A typical family of four on a public water supply uses about 350 gallons per day at home. In contrast, a typical household that gets water from a private well or cistern uses about 200 gallons / day for a family of four. In our communities an additional 35 gallons of water per person are used for public activities such as fire fighting, car and street washing, and park maintenance. Commercial and industrial businesses may also place heavy demands on public water supplies in developed countries. In most water supply systems, the predominant number of user connections are residences, but the few connections to nonresidential customers may account for a significant portion of the system-wide water use.

4. STAKEHOLDERS

Safe drinking water is the concern of a multitude of people in a national setting. Following is a list of stake-holders as far as the issue of safe drinking water is concerned.

4.1 Community

The community's stake is survival through access to clean drinking water.

4.2 Public Sector

The Government has a duty towards the community to provide basic living rights to the population. Water is one of the essentials for human survival. In Pakistan the major sectors related with water issues are the municipal corporations, the EPS and the Ministry of Science and Technology through the PCRWR (Pakistan Council for Research in Water Resources). At the Federal level the Capital Development Authority is responsible for water supply and assurance of water quality. The supportive agencies like the National Institute of Health and Ministry of Environment have a role in ensuring quality.

4.3 Health Sector

Almost 70% of the diseases are water related. As such the Ministry of Health and its subsidiaries have a major role in helping improve quality of water, as improvement in quality will help reducing water related diseases. An advocacy role by the health personnel can go a long way in this regard.

4.4 Private Sector

The private sector is into drinking water now for quite sometime. The bottled water is an example of the private sector pitching in to supply clean drinking water. Supply of best quality clean water supply is their responsibility. The private sector is also involved in producing equipment for cleaning water, both at a large scale and for domestic use. Making such equipment accessible to the common man can be of a great help.

4.5 Politicians

Politicians have a mandate from the public to do legislation for the betterment of the public. Issues regarding public health focus special merit as such. Safe drinking water supply should be a priority agenda for them.

4.6 Donor Agencies

Donor agencies are striving for sustainable development. There is a lot of focus on environmental health issues in this context, e.g. DFID is working on water quality monitoring and management program.

4.7 NGOs

Working on environmental issues is also a concern for the NGO's. e.g. The NETWORK for Consumer Protection is working towards public health issues.

5. CONSUMPTION PATTERNS

For thousands of years we have found it necessary to control water — in order to have it where we want it, when we want it. Nonetheless, some areas still suffer from drought, and some from flood. This is due partly to the natural variability of climate and partly to inappropriate land and water use. Now climate seems to be changing beyond that natural variability, and this is having an impact on the availability and distribution of water.

At the same time, other stresses on water are increasing. The amount of fresh water is limited, and the easily accessible sources have been developed. Not only do more people than ever before have to share this resource, but the world population is expected to double by 2050, if it continues to grow at the present rate.

A larger population will not only use more water but will discharge more wastewater. Water quality programs are not fully developed even in the industrialized countries and are nonexistent in most developing countries, where they are most needed. Furthermore, the costs for managing water supplies are increasing, as are the demands on limited financial resources.

5.1 USE OF WATER

On average, our society uses almost 100 gallons of drinking water per person per day. Traditionally, water use rates are described in units of gallons per capita per day (gpcd), i.e. gallons used by one person in one day. Of the "drinking water" supplied by public water systems, only a small portion is actually used for drinking. As residential water consumers, we use most water for other purposes, such as toilet flushing, bathing, cooking, cleaning, and lawn watering.

The frequency of water we use in our homes varies during the day:

- Lowest rate of use - 11:30 p.m. to 5:00 a.m.
- Sharp rise/high use - 5:00 a.m. to noon.
- Peak hourly use from 7:00 a.m. to 8:00 a.m.
- Moderate use - noon to 5:00 p.m. (Lull around 3:00 p.m.)
- Increasing evening use - 5:00 to 11:00 p.m.
- Second minor peak, 6:00 to 8:00 p.m.

5.2 BOTTLED WATER

5.2.1 Types:

There are several types of bottled water available, depending upon the source of the water and the methods used to treat it. Mostly these are:

5.2.1.1 *Artesian Water*

This is water from a confined aquifer that has been tapped and in which the water level stands at some height above the top of the aquifer.

5.2.1.2 *Fluoridated*

This type of water contains added fluoride.

5.2.1.3 *Ground Water*

This type of water is from a subsurface saturated zone that is under a pressure equal to or greater than atmospheric pressure.

5.2.1.4 *Mineral Water*

Mineral water contains at least 250 parts per million total dissolved solids, comes from a source tapped at one or more bore holes or springs, and originates from a geologically- and physically-protected underground water source. No minerals may be added to this water.

5.2.1.5 *Purified Water*

This type of water has been produced by distillation, deionization, reverse osmosis, or other suitable processes and which meets the definition of "purified water". Purified water may also be referred to as "demineralized water."

5.2.1.6 *Sparkling Water*

Sparkling water contains the same amount of carbon dioxide that it had at emergence from the source. The carbon dioxide may be removed and replenished after treatment.

5.2.1.7 *Spring Water*

This type of water comes from an underground formation from which water flows naturally to the Earth's surface

Bottled water is not necessarily safer than the tap water. Bottled water and tap water are both safe to drink if they meet the health standards, although people with severely compromised immune systems and children may have special needs. Some bottled water is treated more than tap water, while some is treated less or not treated at all. On a per gallon basis, bottled water costs much more than tap water. Bottled water is valuable in emergency situations (such as floods and earthquakes), and high quality bottled water may be a desirable option for people with weakened immune systems. Consumers who choose to purchase bottled water should carefully read its label to understand what they are buying, whether it is a better taste, or a certain method of treatment.

6. NATURALLY OCCURING POLLUTANTS

There is no such thing as naturally pure water. Water has been called the universal solvent because so many substances will dissolve in it. In nature, all water contains some impurities. The composition of water varies widely in its main inorganic constituents which are sodium, potassium, barium, lead and iron, etc. Organic compounds like pesticides, detergents, lindane, phenolic substances and carboxylic acids are also examples of water pollutants[2]. Water also can carry many materials in suspension. Unfortunately, water is not particularly selective in which compounds become dissolved or suspended.

Major causes of surface water pollution are summarized in the following table[3]:

Causes	Percentage Distribution
Non-point sources	65
Municipal sources	17
Dredge and Fill	6
Industrial Sources	3
Unknown Sources	9

Table 1: Percentage distribution of water pollution causes

As water flows in streams, sits in lakes, and filters through layers of soil and rock in the ground, it dissolves or absorbs the substances that it touches. Some of these substances are harmless. In fact, some people prefer mineral water precisely because minerals give it an appealing taste. However, at certain levels minerals, just like man-made chemicals, are considered contaminants that can make water unpalatable or even unsafe. Some contaminants come from erosion of natural rock formations. Other contaminants are substances discharged from factories, applied to farmlands, or used by consumers in their homes and yards.

Pollutants can also be directly added to water during contaminant spills or discharge from factories, agricultural operations, etc. Soil and rock can do a good job of filtering some pollutants out of the water as it percolates through them and into the aquifers. That is one reason ground water tends to be less contaminated than surface water.

[2] Halim, Azhar, Dr., *Determination of Drinking water Quality from source to the consumer in Islamabad*, 1996, p.3

[3] Shahab, Saqib, Dr., *Water Pollution*, MPH Course Handouts, Health Services Academy, Islamabad, 2000

7. DRINKING WATER AND HUMAN HEALTH

Water is intimately linked to health in several ways. It is important to address the increasing need for adequate and safe water to protect both people and the planet. Over two million people most of them children die each year of diarrhoeal disease linked to inadequate water supply, hygiene; another million die of malaria; in China alone, 30 million suffer from chronic fluorosis, and 1.5 million are infected with hepatitis "A". UN Water expert, Brian Appleton comments, "5,000 children die needlessly each day from water-borne illnesses"[4]. Improved water quality, sanitation and personal hygiene significantly reduce the spread of these and many other water-related diseases. Better water resources planning and management have a similar beneficial impact on the incidence of malaria, schistosomiasis and other vector-borne diseases(Fig.5)

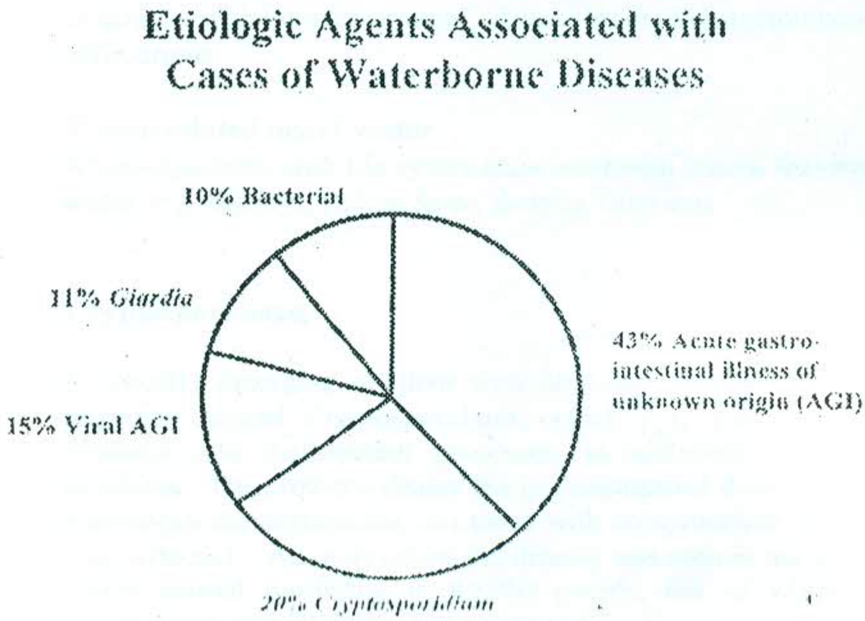


Fig. 6. Showing Water Borne Gastrointestinal Diseases Pattern

Preventing disease helps to alleviate poverty. The 1.1 billion people without access to even improved water sources and the 2.4 billion without basic sanitation include the poorest people in the world – and some of the unhealthiest. A first step towards alleviating poverty is to acknowledge the many components as well as note the major contribution of water and sanitation to poverty alleviation and development.

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[4] Appleton, Brian, quoted by APP, *One billion people have no access to safe water*, The NEWS, Islamabad, March, 2000

7.1 Classification of Water related Illnesses

7.1.1 Waterborne

The route is faeco-oral, and the pathogens originate in the faecal material and are carried by ingestion. Examples are Cholera, Giardiasis, Salmenollosis, Poliomyelitis, Diarrhea and E.coli

7.1.2 Water-washed

Pathogens originate in the feces and are transmitted through contact because of lack of sanitation and hygiene, e.g. infectious eye and skin diseases, relapsing fever, etc.

7.1.3 Water-based

Organisms originate in water and spend part of their life cycle in water and come in contact with humans in water. Examples are Schistosomiasis, helminthic infestations.

7.1.4 Water-related insect vector

Microorganisms with life cycles associated with insects that live or breed in water, e.g. Malaria, yellow fever, dengue, filiariasis

7.2 Cryptosporidiosis

A recently emerging problem with drinking water has been the presence of a pathogen named Cryptosporidium, which may pas through water treatment filtration and disinfection processes, in sufficient amount to cause health problems. The protozoa causes the gastrointestinal disease cryptosporidiosis. All individuals are susceptible, but those with compromised immune systems are the most affected. An outbreak of the disease was seen in the USA, in the year 1993, which caused morbidity in 40,000 people, out of which some 4,000 were hospitalized, and 50 deaths were reported.

The most common symptom of cryptosporidiosis is watery diarrhea. There may also be abdominal cramps, nausea, low-grade fever, dehydration, and weight loss. Symptoms usually develop 4 to 6 days after infection but may appear anytime from 2 to 10 days after infection.

People with healthy immune systems are usually ill with cryptosporidiosis for several days but rarely more than two weeks. Some infected individuals may not even get sick. Some people with cryptosporidiosis seem to recover, then get worse again. Those who are infected may shed oocysts in their stool for months, even after they no longer appear to be ill.

Cryptosporidiosis may cause complications for those with illnesses or conditions such as diabetes, alcoholism, or pregnancy. The effects of prolonged diarrhea and dehydration can be dangerous, especially for the very young, the elderly, and the frail.

Drinking untreated surface water (such as streams, rivers, and lakes) or swallowing a small amount of water when swimming, even in a chlorinated pool, can cause cryptosporidiosis.

Oocysts are not killed by typical household disinfectants, including bleach, but are killed at temperatures over 160 F (hotter than most domestic hot tap water). Thorough drying in a clothes dryer will kill oocysts by desicating them[5].

A brief summary of the various diseases which are related with water and the associated Morbidity and Mortality is shown here (Table 3).

Estimates of Global Morbidity & Mortality of Water-Related Diseases (Early 1990's; WHO)

Disease	Morbidity (episodes/year or people infected)	Mortality (deaths/year)
Diarrheal diseases	1,000,000,000	3,300,000
Intestinal helminths	1,500,000,000 (people infected)	100,000
Schistosomiasis	200,000,000 (people infected)	200,000
Dracunculiasis	150,000 (in 1996)	—
Trachoma	150,000,000 (active cases)	---
Malaria	400,000,000	1,500,000
Dengue fever	1,750,000	20,000
Poliomyelitis	114,000	--
Trypanosomiasis	275,000	130,000
Bancroftian filariasis	72,800,000 (people infected)	----
Onchocerciasis	17,700,000 (people infected; 270,000 blind)	40,000 (mortality caused by blindness)

Table 2. Global data Morbidity and Mortality of water-related diseases[6]

[5] www.who.int , *Frequently asked questions about Cryptosporidiosis*, 2000
[6] www.who.int , *Estimates of global morbidity and mortality from water-related illnesses*, 1999

8. HAZARDOUS POLLUTANTS vis-à-vis HUMAN HEALTH

The United States EPA has set standards for more than 80 contaminants that may occur in drinking water and pose a risk to human health. EPA sets these standards to protect the health of everybody, including vulnerable groups like children. Water contamination has become the principal environmental concern for the next decade and beyond. Rainwater flushes airborne pollutants from the skies that ends up in rivers, streams, lakes and other reservoirs. Ground water can remain polluted for years, because nature supplies few, if any, cleaning or diluting forces[7]

8.1 Sources of Drinking Water Pollution

8.1.1 *Human*

We the human beings, the major beneficiaries from water are too callous towards keeping our water clean, and mostly pollute our own water

8.1.2 *Biological*

Pathogenic microorganisms remain the most important danger to drinking-water. Contamination by coliform bacteria has proved to be the most dangerous of all biological pollutants

8.1.3 *Industrial*

Industrialization which has brought relief in many walks of life; is also a hazard to the natural resources, water being one. Most of the chemical contamination of water comes from the industry.

8.1.4 *Agricultural*

Fertilizers and pesticide use has known to be a source of water contamination. This specially damages the sub-soil water reservoirs

8.1.5 *Engineering Defects*

Leaky septic systems are a common problem in most sanitation and water supply networks, which results in mixing of waste water with water used for drinking purposes. Improperly installed and maintained household storage tanks may also be sources of contamination.

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[7] Omar, Kaleem, *Your drinking water may look good, taste good, and smell good, but it could still be killing you*, The NEWS, July, 2000. pp 22,23

8.2 Acute effects:

These occur within hours or days of the time that a person consumes a contaminant. People can suffer acute health effects from almost any contaminant if they are exposed to extraordinarily high levels (as in the case of a spill). In drinking water, microbes, such as bacteria and viruses, are the contaminants with the greatest chance of reaching levels high enough to cause acute health effects. Most people's bodies can fight off these microbial contaminants the way they fight off germs, and these acute contaminants typically don't have permanent effects. Nonetheless, when high enough levels occur, they can make people ill, and can be dangerous or deadly for a person whose immune system is already weak due to HIV/AIDS, chemotherapy, steroid use, or another reason.

8.3 Chronic effects

These occur after people consume a contaminant at levels over EPA's safety standards for many years. The drinking water contaminants that can have chronic effects are chemicals (such as disinfection by-products, solvents, and pesticides), radio-nuclides (such as radium), and minerals (such as arsenic). Examples of the chronic effects of drinking water contaminants are cancer, liver or kidney problems, or reproductive difficulties.[8]

Categories for Faecal Coliform Densities		
Category	*Coliforms 100ml*	*Health Risk*
A	0	No risk
B	1-10	Little risk
C	11-50	Intermediate risk
D	>50	High risk

Table 3: Showing Coliform Densities in water

8.4 Coliform Bacteria

Coliforms are bacteria that are naturally present in the environment and are used as an indicator that other, potentially-harmful, bacteria may be present. Fecal coliforms and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.

[8] What are the health effects of contaminants in drinking water: Ground and Drinking water, USEPA Office of Water, Jan '02

8.5 Major Chemical Water Pollutants:

8.5.1 LEAD

Lead is a serious threat to human health and can adversely affect almost every organ in the human body. Lead contamination usually occurs in the home as water dissolves lead from household plumbing made with lead containing materials. Even many "lead-free" fixtures still contain some lead.

Boiling the water will not reduce the amount of lead. Young children and pregnant women have the greatest risk from even short term lead exposure. An adequate calcium intake can help protect against lead poisoning.

8.5.2 ALUMINIUM

Aluminum has aesthetic implications as it causes discoloration of water.

8.5.3 CHLORIDE

Chloride adds bad taste to water; is smelly and results in pipe corrosion.

8.5.4 CHROMIUM

Chromium, which has recently gained noticeable importance, as studies have shown high levels of chromium in water, is a harmful metal for the human health. It causes liver, kidney, skin and gastro-intestinal disorders.

8.5.5 IRON

Presence of iron in the water causes discoloration of water, staining of utensils and gives a bad taste to water

8.5.6 MANGANESE

Discoloration, adding odor and causing a bad taste, are all attributes that are due to presence of manganese in water

8.5.7 SILVER

Skin ailments are a common manifestation of silver in water.

8.5.8 ZINC

Zinc gives bad taste to water.

8.5.9 ARSENIC

Recent studies in Bangladesh show a very high level of Arsenic in the water. The chemical has many health implications. This has resulted in lowering of the minimum acceptable level of Arsenic from 50 ppb, which had been the acceptable level for nearly half a century, to 10ppb[9]. The syndrome of various symptoms associated with arsenic ingestion through water has been termed Arsenicosis, which involves hands and foot dermatitis and skin ulcers etc.

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[9] Whitman, Christie, *EPA Report*, USEPA, October, 2000

8.5.10 ANTIMONY

Some people who drink water containing antimony well in excess of the Maximum Contaminant Level over many years could experience increases in blood cholesterol and decreases in blood sugar.

8.5.11 ASBESTOS

People who drink water containing asbestos in excess of the Maximum Contaminant Level over many years may have an increased risk of developing benign intestinal polyps.

8.5.12 BARIUM

Drinking water containing barium in excess of the Maximum Contaminant Level over many years could experience an increase in their blood pressure.

8.5.12 BERYLLIUM

People who drink water containing beryllium well in excess of the Maximum Contaminant Level over many years could develop intestinal lesions.

8.5.13 CADMIMUM

Consuming water containing cadmium over a long time can cause kidney diseases.

8.5.14 MERCURY

Kidney damage is attributed to long term uses of water containing mercury.

8.5.15 NITRATE / NITRITE

Infants below the age of six months who drink water containing nitrate in excess of the Maximum Contaminant Level could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.

8.5.16 SELENIUM

Selenium is an essential nutrient. However, some people who drink water containing selenium in excess of the Maximum Contaminant Level over many years could experience hair or fingernail losses, numbness in fingers or toes, or problems with their circulation.

8.5.17 THALLIUM

People who drink water containing thallium in excess of the Maximum Contaminant Level over many years could experience hair loss, changes in their blood, or problems with their kidneys, intestines, or liver.

A table showing maximum levels of the afore mentioned chemicals in water is given below, along with their health effects.

CHEMICAL	MAXIMUM LEVEL (mg/Liter)	HEALTH EFFECTS
Lead[10]	0.010	Lead poisoning
Aluminum	0.2	Discoloration of water
Chloride	250	Taste, smell, pipe corrosion
Chromium	0.1	Liver, Kidney disorders, skin and GI Problems
Iron	0.3	Taste, staining, discoloration
Manganese	0.05	Taste, staining, discoloration
Silver	0.1	Skin disorders
Zinc Arsenic*	5.0 0.010	Taste Arsenicosis

Table 4: Some chemical contaminants of water, threshold levels and Health Effects

8.6 Radioactive Contaminants

Radioactive contaminants have wide ranging health effects, most common of which are skin ailments and carcinogenicity. Some of these are enumerated as follows:

8.6.1 Beta/photon emitters:

Certain minerals are radioactive and may emit forms of radiation known as photons and beta radiation. Some people who drink water containing beta and photon emitters in excess of the Maximum Contaminant Level over many years may have an increased risk of getting cancer.

8.6.2 Alpha emitters:

Certain minerals are radioactive and may emit a form of radiation known as alpha radiation. Some people who drink water containing alpha emitters in excess of the Maximum Contaminant Level over many years may have an increased risk of getting cancer.

8.6.3 Combined Radium 226/228:

Some people who drink water containing radium 226 or 228 in excess of the Maximum Contaminant Level over many years may have an increased risk of getting cancer.

[10] PSQCA Drinking Water Standards,2002
* PSQCA Drinking Water Standards,2002

9. WATER TREATMENT

9.1 HISTORY

The earliest known apparatus for clarifying water was pictured on Egyptian walls in the 15^{th} and 13^{th} Centuries B.C. A similar knowledge of water treatment is available in Sanskrit[11]

Over the time standards for water quality have significantly increased concurrently with a marked decrease in raw-water quality. As populations throughout the world multiply at an alarming rate, environmental control becomes a critical factor. Thus water that is made available for drinking purposes still needs to be purified to be rendered safe for human health.

9.2 PHYSICAL METHODS OF CLEANING WATER

9.2.1 Filtration

Filtration (generally in combination with coagulation and flocculation) is used for the removal of all the insoluble impurities present in water. For the river water, which contains a lot of sand and silt along with other insoluble matter, the water cannot be directly put to any kind of filtration process. The system will choke within minutes. Pretreatment is necessary. This includes coagulation which is done by the addition of coagulants which cause the colloidal clay, and the other finely divided insoluble matter to built up to bigger particles, increase their weight and help them to sink to the bottom of the tank. In this way we remove, most of the insoluble matter before the water is put to the filtration process.

9.2.2 Desalination

Desalination is the partial or complete removal of salts from a water supply. May it be sea water, surface or ground water. Salts in excessive quantities in a supply is often undesirable for drinking or industrial purposes. Various methods are used for the removal of soluble salts present in a water supply.

Although every element present in the earth crust is likely to found in natural water, in macro/micro or sub-micro quantities, but the more frequently elements found in major quantities are Calcium, Magnesium, Sodium and Potassium with minor quantities of Iron and zinc, along with the matching neutralizing radicals and ions like bicarbonates, chlorides and sulphates, with minor quantities of Nitrates. Although this is generally valid but is not the rule. There are principally four methods available for the removal of soluble salts from water (Desalination):

[11] M. N. Baker, *The Quest for Pure Water* (New York: American Water Works Association, 1949)

- Distillation (normal or solar)
- Reverse Osmosis
- De-ionization, through exchange resin
- Electro-dialysis

9.2.2.1 Distillation

Distillation of water is an age old process. In this the water is heated in a vessel and is converted to vapors. The vapors are then condensed to form pure water. All the soluble salts remains in the boiler or vessel. The process is simple but industrial equipment is more sophisticated and complicated. Distillation is an expensive process and the volatile organic impurities and the dissolved gases cannot be removed by distillation method.

9.2.2.2 Reverse Osmosis

A semi permeable membrane, is selective about what it allows to pass through, and what it prevents from passing. These membranes in general pass water very easily because of its smaller molecular size; but prevent many other contaminants from passing by trapping them. Water will typically be present on both sides of the membrane with each side having a different concentration of dissolved minerals. Since the water in the less concentrated solution seeks to dilute the more concentrated solution, water will pass through the membrane from the lower concentration to the greater concentration side. Eventually, osmotic pressure(caused by the difference in the water levels) will counter the diffusion process exactly, and an equilibrium forms.

The process of reverse osmosis forces water with a greater concentration of contaminants (the source water)into that side containing water with an extremely low concentration of contaminants(the processed water). High water pressure on source side is used to "reverse" the natural osmotic process. With the semi-permeable membrane still permitting the passage of water while rejecting most of other contaminants (salts etc). The specific process through which this occurs is called ion-exclusion, in which a concentration of ions at the membrane surface form a barrier that allows other water molecules to pass through while excluding other substances.

Reverse Osmosis in the technically more practical form is widely used in these days for the removal of dissolved salts, bacteria, virus from the water very widely.

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9.3 CHEMICAL METHODS OF CLEANING WATER

Disinfection is the most important process from a health and safety point of view. Disinfection is necessary to destroy pathogenic bacteria and other harmful organisms. There are several methods of disinfection:

- Chlorination
- Thermal Treatment
- Ultraviolet Treatment
- Ozone Gas Treatment
- Misc. methods using, Iodine, Bromine and Silver compounds etc.

Centrally treated water is disinfected at the treatment plant. Home-owners on private wells must disinfect their own water to make it bacteriologically safe for drinking.

9.3.1 Chlorination

The use of chlorine and its compounds is undoubtedly the most common disinfection method used throughout the world. Chlorine is known to be effective against bacteria, and requires short to moderate contact time. It is readily available in several forms and unlike some of the other methods, a simple test exists to measure its effectiveness through what is called residual chlorine.

Chlorine has its limitations. Its solutions are only moderately stable and organic matter as well as iron and manganese can consume chlorine. High chlorine concentrations have objectionable tastes and odors. Despite these drawbacks, chlorination is widely used for municipal water treatment as well as small private water systems.

On addition of Chlorine to water, almost immediately inorganic materials such as dissolved iron and manganese are oxidized and converted to insoluble forms. Chlorine also reacts with organic matter that might be present, usually breaking it down into simpler substances. Reactions with organic matter are much slower, and as a result much longer contact between the organic matter and chlorine is necessary to complete these reactions. Chlorine will kill bacteria given appropriate contact time for given concentration.

The following figure shows why chlorine is the most favorable agent for disinfecting water used for drinking by humans.

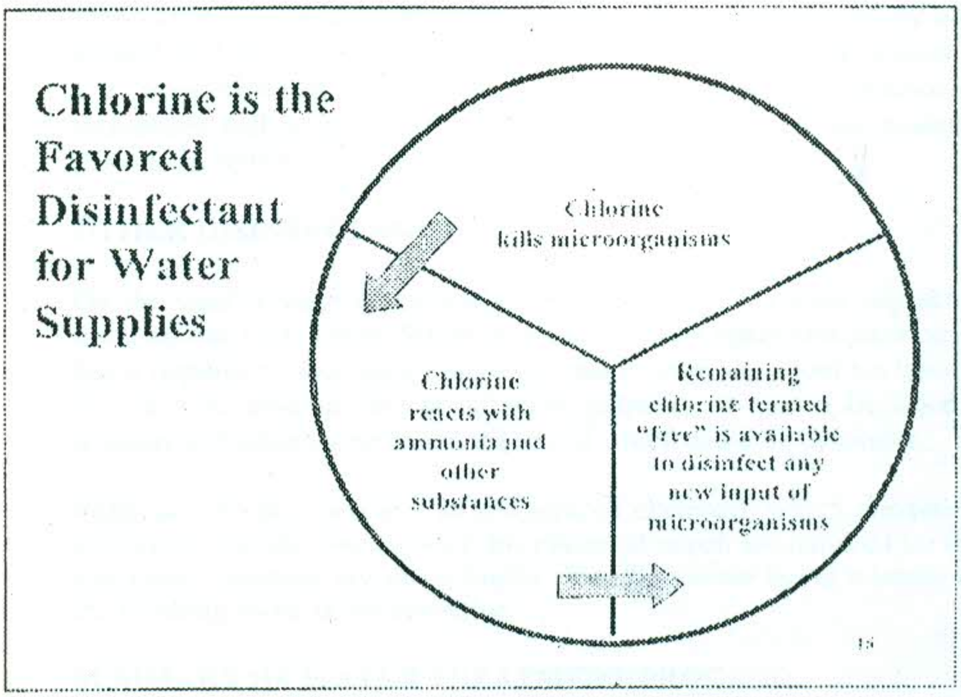

Fig 7. Chlorine as a water disinfectant

9.3.2 Boiling

Boiling renders water safe from many impurities and frees it of bacteriological contamination.

9.3.3 Ultraviolet Treatment

A relatively newer concept in purifying water --- the use of UV rays to disinfect water, is becoming common in both the developed and developing countries. Throughout the 1980's they became more widely used in industrial and commercial applications, and with the development of new materials and commodity production of components, UV units are now becoming popular for residential use.

The UV design is not complicated. Its main component is UV light source, which is enclosed in a transparent quartz sleeve. It is mounted so that water can pass through a flow chamber, and UV rays are admitted and absorbed into the stream. These rays destroy bacteria and inactivate many viruses.

UV, like distillation, disinfects water without adding chemicals, and therefore possesses some of the same benefits as distillation. It does not create new chemical complexes, nor does it change the taste or odor of the water, and does not remove any minerals in the water.

Ultraviolet devices are most effective when the water has already been partially treated, and only the water free from inorganic contaminants passes through the UV flow chamber. UV devices are therefore often combined with other techniques such as carbon filters, water softeners, and reverse osmosis systems to provide complete water quality solutions.

9.4 OTHER DISINFECTANTS

On the smaller scale numerous other disinfectants has been suggested. Silver is more known than others. Silver ions can disinfect water and increase its shelf life but it requires a much longer time for disinfection, say about ten hours. To reduce the reaction time for the disinfection purposes, it has to be laced with some quantity of hydrogen peroxide, the use of which could be debatable.

Potassium Permanganate is an old type of chemical, which remained in use for sometime. But the quantities of this chemical which are required for the killing of pathogenic bacteria are much higher than the human being tolerate so its use in the drinking water is not advisable.

9.5 SUMMARY OF WATER TREATMENT PROCESS:

The following figures shows the various steps that are involved in treating water, so as to make it suitable for drinking purposes.

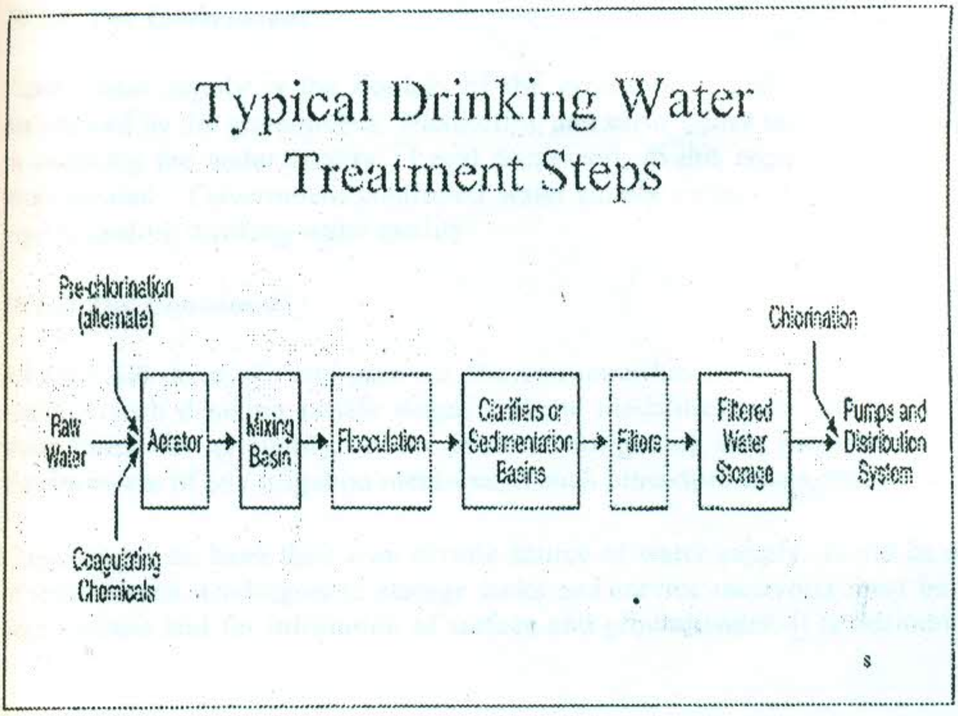

Fig. 8: Typical Drinking Water Treatment Steps

enclosing underground storage tanks to be fenced off to prevent access by humans and animals and to prevent damage to the structures.

11. STANDARD SETTING PROCESS

National water quality standards need to be established and enforced for:

- Quantity of water supplied
- Unrestricted and continuity in drinking water supply for the consumers
- Uniform distribution of water for the whole population
- Control of chemical and microbiological quality of water
- Taking into consideration aesthetic standards of drinking water
- Cost control

The water quality standard setting process should ideally be carried out in the following manner:

- Assessing national water supply status
- Studying guideline recommendations
- Assessing cost of achieving guideline levels
- Assessing available resources and expertise for water supply improvement
- Establishing standards
- Periodic review of water supply status and national levels of compliance
- Review and revision of standards from time to time on need basis

Framework for Drinking Water Quality Standards

- Statement of legal instrument
- Mention of applicable documents
- Detailed description of requirements
- Statement of monitoring, reporting and inspection systems
- Statement of penalties for contravention

12. CURRENT ACTIVITIES ON DRINKING WATER IN PAKISTAN

Per capita water availability in Pakistan was 5300 Cubic Meters in the year 1996, where as it has shrunk to 1300 cubic meters now (October 2001) .The scarce level is 1000 cubic meters, which is not far off. This information is a critical warning , of the fast approaching drought condition, If the rain pattern does not change and demands our serious attention towards water conservation in drinking / hygiene, irrigation use, water sports and industrial use.

Water crisis is the gravest problem faced by today's Pakistan. While the country's two main reservoirs, Tarbela and Mangla, are down virtually to their last drops, a long, dry spell has added to the grimness of the situation and there are no immediate chances of further replenishment of the fast depleting resources.

The immediate need is to ensure the most judicious use of the available supplies for both irrigation and domestic purposes.

Since there is a lack of awareness among the general public about the purity of water one seldom bothers to get the sample of wells' water tested at a laboratory prior to consuming it, the cases of abdominal pain, diarrhea, and other gastro-intestinal diseases, particularly among children and elderly people, were being reported in a considerably large number.

There is a little doubt that the situation is mainly because of natural weather patterns, which have incidentally turned adverse to us. However, many also subscribe to the opinion that the situation has been worsened by non-natural elements. Actors ranging from individual citizens to State-run organizations have failed to respond to the situation in a rational mode.

12.1 WATER-SECTOR SHORTCOMINGS IN PAKISTAN

Due to the fact that operation and maintenance of water supplies and sanitation in developing countries is highly neglected, official data on the numbers of people served by these services often are overly optimistic because, in reality, many of these facilities are broken or operating at reduced capacity. In most cases management systems have failed to provide the necessary guidance and structure for effective operation and maintenance of water supply and sanitation facilities. The deterioration of these valuable physical assets is a major loss to national economies, which can and should be avoided.

Many reasons have been identified as contributing to or causing the failure of water supply systems. These range from poor organizational structures in the responsible agency, lack of spare parts, inappropriate technology, lack of trained staff, tied aid, absence of career opportunities, insufficient funds, legal framework problems, lack of motivation by sector personnel, non-involvement of the users, the low profile of operation and maintenance in the sector in general, inadequate tariff and collection systems and negative political interference. These causes tend to be interrelated and intertwined.

The key issues contributing to poor performance of water supply facilities have been identified as:

- Inadequate data on operation and maintenance
- Insufficient and inefficient use of funds
- Poor management of water supply facilities
- Inappropriate system design
- Low profile of operation and maintenance
- Inadequate policies, legal frameworks and overlapping responsibilities

12.1.1 Inadequate Data:

There is an overall lack of data regarding operation and maintenance. Precise, accurate data on the number of systems which are not working; are needed together with information on the main reasons why. Detailed figures are also necessary to determine how much it costs to undertake an adequate operation and maintenance program for different types of facilities. Data are also required on the rates of breakdown of different systems such as pumping stations, distribution networks, treatment plants in urban systems.

Until this information is forthcoming it will be impossible to accurately assess the performance of operation and maintenance and compute the financial losses due to poor operation and maintenance. These exact financial data are urgently needed to demonstrate to decision makers the advisability of implementing good operation and maintenance programs in order to reduce losses to national economy.

12.1.2 Insufficient and Inefficient Use of Funds:

Insufficient funding has been identified as a major contributor to poor operation and maintenance performance. This lack of funds hampers the operating and maintaining of water supply facilities as money is not available to buy spare parts, properly train staff and provide competitive salaries to attract high caliber personnel. National governments are frequently stressed for cash, especially hard currency which is needed to pay for spare parts and the water supply agencies usually lose out to other, judged more important higher profile sectors.

The users are a potential source of finance for water supply systems. They are often unable or unwilling to pay. Usually it is that they are unwilling to pay rather than unable to. Evidence is mounting that even in the poorest and most underprivileged segments of the community people are willing to pay for a reliable, adequate supply of clean water but unwilling to be charged for an unreliable and unsatisfactory service. It is a vicious cycle. As the service level drops due to a lack of operation and maintenance the users withhold support and become less willing to pay which further constrains operation and maintenance activities.

True wastage should not be significantly above 10% once illegal connections, free supplies, and leakage are reduced to acceptable levels and adequate metering, billing and collections procedures are maintained. High rates of unaccounted for water, whether they are caused by illegal connections, leakage, free water supply, or the result of inadequate commercial operations, result in significant financial losses and consequent poor service performance of the water supply authority.

12.1.3 Management of Water Supply Systems:

The operation and maintenance of water supply facilities throughout the world is undertaken by a wide range of differently structured agencies. These range from community owned and operated water supply systems at one extreme to government owned and operated utility companies at the other. Some agencies are very small and may only be responsible for the supply to a small rural village using a low cost technology while other agencies may be controlling a utility employing thousands of staff and operating a high technology system.

However, no matter what the scale of the facility, the system will perform poorly if it is not managed efficiently and well. The inefficient organization of many water supply agencies is a serious deficiency. If the organizational structure does not promote and allow efficient operation then the overall management will function poorly.

Personnel problems are another reason for poor management performance. Low salaries, absence of career structures, lack of trained personnel and the low profile of operation and maintenance as compared to new construction are all constraints.

Often the consumers are not involved in the water supply agency and there is no feedback from the consumers to the management of the agency. This is particularly acute in government owned and operated agencies which tend to be bureaucratic. This non-involvement of the users in the management of the agency results in stress and in some cases the development of a confrontational relationship between the agency and the consumers. Studies of well run water supply agencies have shown that good customer relations and a sense of management responsibility to the users are common denominations in these organizations, contributing to their overall success.

Consumer participation must begin with the design stage, e.g. the intended user must determine what he is willing and able to pay for. Subsequently, management and operation of the agency must convince the user that he receives full value for the payment he makes. The means of doing so, other than providing good service, vary again with the local conditions and range from direct participation in the management by the user through boards or committees, public meetings, consultations and other participatory activities.

12.1.4 Inappropriate System Design:

No matter how good the management of a water supply facility is, if it is not well designed technically, it will operate inefficiently. Many water supply facilities have been badly designed, poorly constructed and use technologies which are inappropriate. When a facility is improperly designed and constructed even with the best will in the world it cannot perform satisfactorily.

A lack of communication between the system designer and the operators of the system is a further drawback. This applies equally to a rural village receiving a handpump well to an urban centre with complex facilities. The operators of the system need to be familiar with, approve of and be comfortable with the technology. In addition there needs to be a continuous feedback of information from the operators to the designers to pinpoint problems with the design and suggest remedial measures.

12.1.5 Low Profile of Operation and Maintenance:

Operation and maintenance in water supply agencies has a low, and usually an inferior profile as compared to new construction and system extension. Thus for career minded engineers the route to top management positions is recognized to be through new construction and not operation and maintenance.

Within the water sector there is an insufficient appreciation of the magnitude of operation and maintenance problems, importance and the skills required to properly operate and maintain the facilities. In part this is due to a lack of financial data. Accurate costs are not available which will demonstrate to decision makers the financial benefits of good operation and maintenance and conversely the losses to the national economy from poor operation and maintenance. An urgent priority in operation and maintenance is to collect precise figures which clearly show the financial benefits of operation and maintenance to decision makers.

This low priority assigned to operation and maintenance by decision makers is a severe constraint. In order to improve operation and maintenance performance it must be accorded a high priority and importance by national governments in their programs.

12.1.6 Inadequate Policies, Legal Frameworks and Overlapping Responsibilities:

There is a need for clear sector policies, compatible legal frameworks and a clear division of responsibilities and mandates within the water and sanitation subsector. Due in part to the low priority assigned to operation and maintenance, no clearly defined policies have been enunciated which adequately address this issue. Commonly the lines of responsibility between the various organizations involved are often blurred. This is particularly true of the relations between water supply and sanitation where the maintenance agencies usually have no or limited contact.

A possible alternative for the better management of water supply facilities is to devolve the responsibility of managing systems from government to autonomous agencies which will manage the facilities under technical, financial and administrative guidelines from the government. This would greatly limit the extent of political interference by governments and allow the facilities to be managed more efficiently.

12.2 WATER QUALITY RESEARCH

To protect the right of access to clean water by the consumers, an exercise of collecting and analyzing bottled water available in the markets of Rawalpindi and Islamabad has been carried out twice by the Ministry of Science and Technology's Pakistan Council of Research in Water Resources (PCRWR) Islamabad.

The first set of experiments was carried out in late 2000 and the latest in first quarter of the year 2001. The results of the first study were released to the press masking the brand names of manufacturers.

As per the press and PCRWR the water samples were collected (in triplicate) from the twin cities of Rawalpindi and Islamabad in the presence of representatives of district administration, laboratory, food department and consumer representative group of CRCP. A part of samples was sent for cross check analysis of Microbiological examination by private laboratories like Nayab, Excel and Shifa laboratories. It is believed that the results of these independent cross check analysis were fairly in agreement. The experiment design and execution are quite scientific and one does feel satisfied of whatever has been done. Ministry of Science and technology has earned national gratitude by the release of full report for the general use.

PCRWR has rightly pointed out the need for providing analytical facilities at the provincial capitals .It is painful to note that we don't have water quality standards / guidelines for drinking water ~~or bottled drinking water~~.

12.3 WATER TESTING EQUIPMENT

Whereas laboratories for testing water quality are available in all big cities of Pakistan, but as drinking water pollution is a major concern in the rural areas where the underserved communities reside, no such facilities are available. A portable water testing equipment has been devised by OXFAM, which claims to perform tests at your doorstep. A detailed description of the equipment is given below:

The Oxfam-DelAgua water testing kit[13] was devised by scientists at the University of Surrey in collaboration with Oxfam. The kit is designed to help provide rapid information about the safety of water supplies even in emergency situations such as natural disasters, refugee camps, slums and in rural areas where laboratory facilities do not exist. The kit allows five important water quality indicators to be assessed in the field using well-proven and simple methods. **Training of users can normally be done in 1 to 2 days.**

Critical Parameter Tests

The kit will perform the following tests:

- Thermotolerant (faecal) Coliform Count :The kit provides a portable, battery-powered incubator capable of running for 5 days without mains electricity, generator or vehicle power. Thermotolerant (faecal) Coliform counts can be obtained within 14 to 18 hours of sampling giving a reliable indication of sanitary risk without need for transport or laboratory facilities.

- Total Coliform Count : An optional extra is a second portable, battery powered incubator set a t 37 Celsius for the determination of total coliforms in water that indicate contamination of a water supply. Coliform counts can be made within 16-18 hours and give a reliable indication of contamination of water supplies from environmental and other sources.

- Turbidity Test: A measure of the amount of suspended matter in a water supply. Suspended material may consume chlorine disinfectants and require treatment before disinfection.

- Chlorine and pH Tests: Many emergency water supplies are dosed with chlorine disinfectant to ensure their safety as drinking water. These tests allow rapid assessment of chlorine levels and efficient control of dosing thereby avoiding waste and ensuring that enough chlorine is present to safeguard the supply.

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[13] http://www.eihms.surrey.ac.uk/robens/env/delagua.htm

- Other Tests : A conductivity meter is provided as an optional component of the kit. Conductivity provides an indication of contamination e.g. saline intrusion or sewage pollution. Other optional tests can be included for chemicals that may be of local importance.

12.4 CURRENT UPDATE

Research is an ongoing process, and the water issue is no exception. As of the recent month, PCRWR, PAEC, PIC and UNICEF held a seminar on water quality and quantity issue of Pakistan. The most salient recommendations coming out of that seminar can go a long way in developing a National Drinking Water Strategy. These have been summarized below:

- Forming of a National Steering Committee for water management
- National Water Quality Standards to be legislated and enforced
- Water database and website development
- Public awareness through education in schools / colleges / media
- Mitigation program for Arsenic / Flouride in water
- Sewage treatment plants in all cities.
- NEQS enforcement on industrial effluents
- Regularization of ground water exploitation both at the domestic and commercial level
- Availability of facilities for water treatment and up-gradation of equipment
- Joint research projects in public health

13. TOWARDS A HEALTHIER PAKISTAN --- TN's WATER PROJECT'S ROLE

Objectives:

- To encourage, promote, and foster historical understanding of, and research in, the relationship between water and humankind,
- To foster a stronger relationship between those engaged in water history and water administrators, engineers, scientists, planners and other practitioners,
- To foster public awareness of the role of water in world history and to promote public participation in resolving water resource issues,
- To take other actions deemed by the Network to be supportive of its purposes.

We visualize:

- Empowering indigenous and local communities on capacity building and the rights regarding natural resource management specially water
- Strengthening and empowering community rights on environment and their capacity on natural resource management
- Developing local management projects through participatory approach to meet the basic needs of the people
- Raising awareness on indigenous knowledge of environmental issues through popular education, news, and other material for community, government decision makers, and related stakeholders
- Developing field action program at grassroots level to facilitate community-based water resource management, keeping in view their indigenous knowledge and traditional system.
- Developing database on drinking water issues through policy study, ethnographic study, participatory study, and audio-visual aids.
- Developing modules, training, book, booklet, bulletin, and other popular education material related with water rights and responsibilities

- Developing media such as community radio and bulletin as a vehicle for advocacy, dissemination, awareness rising, and monitoring of environmental issues among communities, with a special focus on water issues

Major concerns:

- To undertake research into areas of :
    - o drinking water quality,
    - o water treatment,
    - o ground water pollution, and
    - o sampling and analyses.

- To advise on water related topics on a time-to-time and need basis

- To prepare specific "state of the art" reports either on a confidential basis or for general circulation. Priority areas will be initially:
    - o bacteriological testing, and
    - o testing for other health related parameters.

- To prepare a list of water related experts for consultation and information sharing, locally and internationally

- To provide the consumers and other stake-holders with access to information services

- To provide training facilities for research, lab-based training, team-building and community mobilization

- To hold seminars/ workshops to enhance public awareness and an effort to bring all the stake-holders together.

- To organize working groups and consultations on water-related subjects

- To undertake periodic revisions of the legislation regarding Drinking Water Quality

- To make NETWORK as a complete resource center on water-related issues both in print and electronic format

- To address consumer complaints, through the CCC of the NETWORK

- To propose a National Primary Drinking Water Regulation.

LOGICAL FRAMEWORK

Water Project

The NETWORK for Consumer Protection

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Assumptions / Risks
Supergoal Improved health status of the population	☺ Reduced morbidity and mortality from water-borne diseases ☺ Reduced bacteriological /chemical contamination	☺ Health data (HMIS) ☺ Periodic Lab Tests	☺ Available health data ☺ Reliable lab results
Goal Improved access to quality goods and services which directly affect the health of the poor	Improved access to clean drinking water	Reports by GoP, Donors (All donors working on the water issue), NGOs	☺ Other factors causing disease remain constant ☺ Reliable studies / data
Purpose Protection of right of underserved to improved services, specially water	☺ **Access**: Access to clean drinking water ☺ **Safety / Quality:** Standards formulation Improved lab. facilities ☺ **Information / Mobilization:** Involving community, educational institutions through workshops, seminars, literature ☺ **Redress:** CCC complaints logged reg. water Action taken towards redress	☺ Monitoring reports by GoP, Donors, NGOs ☺ TN's own ongoing research / reports	☺ Constantly improving status of services at the governmental level as a result of TN's efforts ☺ Standards formulated and adherence ensured

LOGICAL FRAMEWORK

.........continued...........

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Assumptions / Risks
Outputs (Phase-I – Apr 2002 to June 2002) **1.TN's capacity to plan, manage and govern the water project**	1.1 Management structure of water project 1.2 Situation Analysis 1.3 Project strategy 1.4 Project planning 1.5 Data Collection at TN level (water experts, tech info., etc)	Quarterly report	Adequate staff and infrastructure to undertake tasks mentioned at column #2
2. Access to clean drinking water (Phase – II, Jul 2002 to Dec 2002)	2.1 Advocacy through community mobilization 2.2 Pursuing formulation of Drinking Water Quality Standards 2.3 Bringing together all stakeholders 2.4 Using Supportive Advocacy vis-à-vis existing Govt. Orgs.	☺ Quarterly report Governments legislative reports (MoST) ☺ UNICEF and other Donors' reports ☺ Water related Agencies' reports (PCRWR / CDA)	☺ Community mobilization team undertaking water as a priority issue ☺ Government committed to improving water situation in the country
3. Quality Control (Phase – III, Jul 2002 to Dec 2005)	3.1 Use of Lab. facilities at GoP level 3.2 Counter-checking of water samples 3.3 Making TN's water lab. functional 3.4 Acquiring portable water testing facilities	Laboratory reports	☺ Adequate technical manpower available ☺ Adequate funds available ☺ Commitment at the Governmental level
4. Quality Assurance (ongoing)	Use of QA systems at the water treatment and supply level	☺ TN's Water Project Reports ☺ Water Provider's Reports	☺ Water providers commitment / public service ☺ Commitment at the Governmental level

LOGICAL FRAMEWORK

.........continued...........

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Assumptions / Risks
5. Redress (ongoing)	5.1 CCC will proactively look for consumers complaints 5.2 Satisfactory complaint handling 5.3 Law and Governance issue dealt with	CCC reports	Adequately functioning and supportive L& G Unit

ANNEXURE - I

Pakistan Data

(All estimates are for the year 1998, except where indicated)

Population	135,135,195
Population Growth Rate	2.2%
Birth rate	34.38 births / 1,000 population
Death rate	10.69 deaths/1,000 population
Sex ratio	at birth: 1.05 male(s)/female under 15 years: 1.06 male(s)/female 15-64 years: 1.05 male(s)/female 65 years and over: 0.99 male(s)/female
Age structure	0-14 years: 44% female: 48.49% male: 51.50% 15-64 years:52% female: 48.79% male: 51.20% 65 years and over : 4% female: 49.50% male: 50.49%
Infant mortality rate	93.48 deaths/1,000 live births
Total fertility rate	4.91 children born/woman
Life expectancy at birth	total population: 59.07 years male: 58.23 years female: 59.96 years
Literacy	***Definition: age 15 and over can read and write*** total population: 37.8% male: 50% female: 24.4%
Religions	Muslim 97% Christian, Hindu, and other 3%
Total area	803,940 sq. km
Land area	778,720 sq. km
Coastline	1,046 km
International disputes	Kashmir problem, Afghan issue, Wular Barrage water sharing problem with India
Climate	Mostly hot, dry desert, temperate in northwest
Terrain	Flat Indus plain in the east; mountainous in north and northwest, plateau in west (Baluchistan)
Natural resources	Land, natural gas reserves, coal, iron ore, copper, salt, limestone
Land use	Arable land : 23%, Meadows / Pastures: 6%, Forests and woodland : 4%, Other: 67%
Irrigated land	170,000 sq km

Source: *http://www.islamabad.net,* 2000

ANNEXURE - II

GLOSSARY OF TERMS

Alkalinity: The capability of water to neutralize acid

Acidity: The quantitative capacity of water or a water solution to neutralize an alkali or base.

Activated Carbon: A granular material usually produced by roasting various grades of coal in the absence of air. It has a very porous structure and it is used in water conditioning as an adsorbent for organic matter and certain dissolved gases. Sometimes called "activated charcoal".

Aerobic: An action or process conducted in the presence of air, such as aerobic digestion of organic matter by bacteria.

Algae: Small primitive plants containing chlorophyll, commonly found in surface water. Excessive growths may create taste and odor problems, and consume dissolved oxygen during decay.

Alum: A common name for aluminum sulphate, used as a coagulant in water treatment.

Amoeba: A small, single celled animal or protozoan.

Anaerobic: An action or process conducted in the absence of air, such as the anaerobic digestion of organic matter by bacteria in a septic tank.

Anion Exchange: An ion exchange process in which anions in solution are exchanged for other anions from an ion exchanger. In demineralization, for example, bicarbonate, chloride and sulphate anions are removed from solution in exchange for a chemically equivalent number of hydroxide anions from the anion exchange resin.

Aquifier: A layer or zone below the surface of the earth which is capable or yielding a significant volume of water.

Atom: The smallest particle of an element that can exist either alone or in combination.

Backwash: The process in which beds of filter or ion exchange media are subjected to flow opposite to the service flow direction to loosen the bed and to flush suspended matter collected during service run.

Bacteria: Unicellular prokaryotic microorganisms which typically reproduce by cell division. Many kinds of bacteria are found in natural waters. Some of them are dangerous while others are harmless.

Biochemical Oxygen Demand (BOD): The amount of oxygen consumed in the oxidation of organic matter by biological action under specific standard test conditions. Widely used as a measure of the strength of sewage and waste water.

Biodegradable: Subject to degradation to simpler substances by biological action, such as the bacterial breakdown of detergents, sewage wastes and other organic matter.

Breakpoint Chlorination: A chlorination procedure in which chlorine is added until the chlorine demand is satisfied and a dip (breakpoint) in the chlorine residual occurs. Further additions of chlorine produce a chlorine residual proportional to the amount added.

Calcium: One of the principal elements in the earth's crust. When dissolved, in water, calcium is a factor contributing to the formation of scale and insoluble soap curds which are a means of clearly identifying hard water.

Carbon Dioxide: A gas present in the atmosphere and formed by the decay of organic matter, the gas in carbonated beverages, in water it forms carbonic acid and cause corrosion in the pipes and the cooling equipment used in industry.

Cartridge: Any removable preformed or prepackaged component containing a filtering media or ion exchanger.

Cathode: The negative pole of an electrolytic system; an electrode where reduction occurs.

Chlorides: Salts of chlorine which are generally soluble. High concentration of chlorides in water causes corrosion problems in industrial water.

Chlorine: A gas, widely used in the disinfection of water and an oxidizing agent for organic matter, iron etc.

Chlorine Demand: A measure of the amount of chlorine consumed by oxidizable substances in water before chlorine residual will be found.

Coagulant: A material such as alum, which will cause the agglomeration of finely divided particles into larger particles which can then be removed by settling and/or filtration.

Coliform Bacteria: A group of microorganisms used as indicators of water contamination, and the possible presence of pathogenic bacteria.

Colloid: Very finely divided solid particles which do not settle out of a solution; intermediate between a true dissolved particle and a suspended solid which will settle out of solution. The removal of colloidal particles usually requires coagulation.

Color: The shade or tint imparted to water by substances in true solution, and thus not removed by mechanical filtration; most commonly caused by dissolved organic matter, but may be produced by dissolved mineral matter. As measured in a water analysis, only the intensity of the color is reported. Color can make the water unappealing to drink. In some waters a yellowish coloration may be present. This color condition is organic in nature, but presents no health hazard. It is caused by the microscopic suspended particles. The color is measured in Hazen units.

Conductivity: The quality or power to carry electrical current; in water related to the concentration of ions capable of carrying electrical current.

Corrosion: The disintegration of a metal by electrochemical means.

Cryptosporidium: A common intestinal parasite found in waters contaminated by sewerage or runoff containing animal waste. It causes diarrhea, nausea, and cramps. Individuals with weakened immune systems are at particular risk. Although resistant to chlorine and most oxidizing agents, it can be used by using a suitable filter.

Deionization: The removal of all ionized minerals and salts from a solution by a two-phase ion exchange process. First, positively charged ions are removed by a cation exchange resin in exchange for a chemical equivalent amount of hydrogen ions. Second, negatively charged ions are removed by an anion exchange resin for a chemically equivalent amount of hydroxide ions. The hydrogen and hydroxide ions introduced in this process unite to form water molecules. The term, commonly abbreviated as DI, is often used interchangeably with demineralization.

Density: The mass of a substance per specified unit of volume; for example, pounds per cubic foot. True density is the mass per unit volume excluding pores; apparent density is the mass per unit volume including pores.

Detergent: Any material with cleaning powers, including soaps, synthetic detergents, many alkaline materials and solvents, and abrasives.

Disinfection: A process in which vegetative bacteria are killed; may involve disinfecting agents such as chlorine, or physical processes such as heating.

Dissolved Solids: The weight of matter in true solution in a stated volume of water includes both inorganic and organic matter; usually determined by weighing the residue after evaporation of the water at 105C or 180C.

E.Coli: The common abbreviation of Escherichia Coli.

Effluent: The stream emerging from a unit, system or process, such as the softened water from an ion exchange softener.

Gallon: A unit of liquid volume; the US gallon has a volume of 231 cubic inches or 3.78533 liters; the British (Imperial) gallon has a volume of 277.418 cubic inches or 4.54596 liters.

Giardia Lamblia: An intestinal parasite commonly found in water supplies originating in mountainous or wooded watersheds. It exists as a free-swimming protozoan-like organism in warm blooded animal's intestines, causing chronic diarrhea, cramps, bloating and weight loss. Outside of the intestines, it forms a tough cyst that protects it until it finds a new host. Resistant to chlorine and most oxidizing agents,

Hardness: A characteristic of natural water due primarily to the presence of dissolved polyvalent cations, such as calcium, and magnesium. Water hardness is responsible for most scale formation in pipes and water heaters, and forms insoluble curd when it reacts with soaps. Hardness is usually expressed in grains per gallon, parts per million, or milligrams per liter, all as calcium carbonate equivalent.

Ion: An atom or group of atoms which function as a unit and have a positive(cation) or negative (anion) electrical charge, due to the gain or loss of one or more electrons.

Liter: A basic unit of volume; 3.785 liters equal 1 US gallon; 1 liter of water weighs 1000 grams

Magnesium: One of the elements in the earth's crust, the compounds of which when dissolved in water make the water hard. The presence of Magnesium in water is a factor contributing to the formation of scale and insoluble soap curds.

MCL: Abbreviation for Maximum contaminant Level; the maximum allowable concentration of a contaminant in water as established in the US, EPA Drinking Water Regulations.

Micron: One thousandth part of a millimeter.

MPN: Most Probable Number, the term used to indicate the number of microorganisms which, according to statistical theory would be most likely to produce the results observed in certain bacteriological tests; usually expressed as a number per 100 ml of water.

Nanometer: Abbreviated "nm", a unit of length equal to one thousands of a micrometer. Often used to express wavelength of ultraviolet light and the colors of visible light in colorimetric analysis.

Nephelometric Turbidity Unit (NTU): An arbitrary unit of measuring the turbidity in water by the light scattering effect of fine suspended in a light beam

Neutralization: The addition of either an acid or a base to a solution as required to produce a neutral solution. The use of alkaline or basic materials to neutralize the acidity of some waters is a common practice in water conditioning, as calcite or magnesia, used in the neutralization of acid waters.

Normal Solution: A solution containing a gram equivalent weight of a substance in one liter of solution.

Odors: Are self descriptive. Odors are sometimes transmitted to the sample by the shipping container when it is not a standard sample bottle.

Organic Matter: Substances of or derived from plant or animal matter. Organic matter is characterized by its carbon-hydrogen structure.

Osmosis: A process of diffusion of a solvent such as water through a semi-permeable membrane which will transmit the solvent but impede most dissolved substances. The normal flow of solvent is from the dilute solution to the concentrated solution in an attempt to bring the solutions on both sides of the membrane to equilibrium.

Oxidation: A chemical process in which electrons are removed from an atom, ion, or compound; causing the substance's valence to increase. The addition of oxygen is a specific form of oxidation; combustion is an extremely rapid form of oxidation; while the rusting of iron is a slow form. Whenever oxidation occurs, an offsetting reduction reaction must occur.

Ozone: An unstable form of oxygen (O3), which can be generated by an electrical discharge through air or regular oxygen. It is a strong oxidising agent and has been used in water conditioning as a disinfectant.

Parts per million (ppm): A common basis for reporting the results of water and waste water analysis, indicating the number of parts by weight of a dissolved or suspended substance, per million parts by weight of water or other solvent. In dilute water solution, one part per million is practically equal to one milligram per liter, which is the preferred unit.17.12 ppm equals to one grain per US gallon.

Pathogen: An organism which may cause disease.

Permanent Hardness: Water hardness due to the presence of chlorides and sulphates of calcium and magnesium, which will not precipitate by boiling. This term is largely replaced by "non-carbonate" hardness.

pH: The negative logarithm of the hydrogen ion concentration. The pH scale ranges from zero to 14 with 7 as the neutral point, indicating the presence of equal concentrations of free hydrogen and hydroxide ions. pH values below 7.0 indicate acidity, with 0 most acid; pH values above 7 indicate basicity, with 14 most basic or alkaline.

Postchlorination: The application of chlorine to a water following other water treatment processes.

Potable water: Water which is fit for human consumption.

ANNEXURE - III

Specifications
and
Current Price List
Oxfam DelAgua

Specifications

- Dimensions:370*140*260mm
- Weight: Approx.10kg
- Incubator: Temperature 44 Celsius, power 12v (internal battery - charger supplied), capacity 16*47mm petri dish
- The kit is supplied with consumables for 200 tests. However, the following items are needed to start testing:
- *Pressure cooker or portable steriliser or access to an autoclave e.g. in hospital.*
- *Methanol (approx. 1ml per test)*
- *Distilled water*
- *1litre measuring cylinder or beaker*

Price List:

Water Testing Kits

Item	*Cost GBP*
Basic Water Testing Kit (44 C)	1130.00
-Battery charger	
-Temperature check kit	
-Consumables for 200 tests	
Double Incubator Kit (44 Celsius & 37 Celsius)	1380.00
-Portable Battery Pack	
-Temperature check kit	
-Consumables for 200 tests	

Optional Extras

Item	*Cost GBP*
Portable Conductivity Meter	260.00
Portable Battery Pack	132.30
Portable Steriliser Kit	92.00

Replacement Parts & Spares

Item	*Cost GBP*
Battery Charger (specify voltage)	49.00
Filtration Apparatus	120.00
Filter Funnel (incl. Collar)	26.00
Sample Cup	18.90
Vacuum Cup	17.00
Vacuum Pump	10.50
Cable (for sample cup)	8.20
Spares Box complete	35.00
Bronze Disc	7.40
Sealing Gasket Set for Bronze Disc (pair)	6.60
Black Rubber O-Ring	1.65
Turbidity Tubes (pair)	37.20
Forceps	4.20
Comparator (Chlorine & pH)	11.60
Battery Leads	10.00
Petri Dishes (x16) & Carrier	17.00
Dish Carrier	2.10
Charger Fuses (x2)	1.00
Polypropylene Bottles (x10)	7.50
Methanol Dispenser	1.65
Trimmer Tool	1.60
Incubator Lid	16.35
Silicone Grease (2g)	0.55
Silicone Grease (100g)	5.80
Temperature Calibration Kit -Thermometer -Calibration Lid -Trimmer Tool	26.00

Consumables

Item	*Cost GBP*
Membrane Filters & Pads (x200)	20.00
Membrane Filters & Pads (x1000)	100.00
Pad Dispenser	6.30
Culture Medium (38.1g tub)	5.00
Culture Medium (500g tub)	30.00
DPD No.1 Tablets (x250)	11.00
DPD No.1 Tablets (x1000)	44.00
DPD No.3 Tablets (x250)	11.00
DPD No.3 Tablets (x1000)	44.00

Phenol Red Tablets (x250)..11.00
Phenol Red Tablets (x1000)..44.00
Methanol (packed for airfreight)..16.00
Consumables for 200 tests..64.30
Extra Manual..2.80

Repair Kits

Item	*Cost GBP*
Battery Replacement Kit	92.00
-New Battery	
-Silicone Sealant	
Electrical Repair Kit	75.00
-Silicone Sealant	
-Trimmer Tool	
-Circuit Board	
-Chip (wired)	
Rucksack	105.00
-Rucksack (modified for transportation of DelAgua kit)	
-3 Removable zipped bags for consumables	

Please Note: These prices are subject to change without notice.

For more information, contact DelAgua (phone: +44 (0) 1483 879209, fax: +44 (0) 1483 879971)
Email: delagua@surrey.ac.uk

updated by Mike Barrett 15/12/2000

ANNEXURE – IV

Relevant Excerpts from Local Bodies Ordinance, 2001

Water Supply

94. Water Supply.—(1) The concerned local government shall provide or cause to be provided to its local area a supply of wholesome water sufficient for public and private purposes.
(2) Where a piped water supply is provided, the concerned local government shall supply water to private and public premises in such manner and on payment of such charges as the by-laws may provide.

95. Private source of water supply.—(1) All private sources of water supply within the local area of a concerned local government shall be subject to control, regulation and inspection by local government.
(2) No new well, water pump or any other source of water for drinking purposes, shall be dug, constructed or provided except with the sanction of the concerned local government.
(3) A concerned local government may, by notice, require the owner or any person having control of any private source of water supply used for drinking purposes—
(a) to keep the same in good order and to clean it from time to time of silt, refuse and decaying matter;
(b) to protect the same from contamination in such manner as the local government directs; and
(c) if the water therein is proved to satisfaction of the local government to be unfit for drinking purposes, to take such measures as may be specified in the notice to prevent the use of such water for drinking purposes.

96. Public watercourses.—(1) A concerned local government may, with the previous sanction of the Government, declare any source of water, river, spring, tank, pond or public stream, or any part thereof in its local area, which is not private property, to be a public water course.
(2) A concerned local government may, in respect of any public watercourse, provide such amenities, make such arrangements for lifesaving, execute such works, and subject to the provisions of any law for the time being in force relating to irrigation, drainage and navigation, regulate the use thereof, as the by-laws may provide.

ANNEXURE – V

A TN's report of water quality in Islamabad / Rawalpindi

Bacteriological contamination and upward trend in Nitrate contents, observed in drinking water of Rawalpindi and Islamabad.

*M.Jahangir**

The Network for consumer protection in Pakistan conducted a drinking water quality survey in July 2001 in the city of Rawalpindi and Islamabad.
Objective of the survey was to have an overview of the drinking water quality in the twin cities and try to correlate this information with the disease burden in the area.

We were able to do this with the collaboration of National Institute of Health (NIH). NIH provided analytical support by analyzing these water samples at half the regular price.

Unsuitable for drinking due to Bacteriological contamination	**94 %**
Samples showing fecal contamination	**34 %**
Unsuitable due to Nitrate Nitrogen	**12.8 %**
Samples showing Nitrate =< 5PPM	**48.9 %**

Number of samples collected	47
Samples from Islamabad	9
Samples from Rawalpindi	38

One sample from Chaklala Railway colony was rejected due to high turbidity.

According to Pakistan Council of Research in Water Resources (PCRWR), Draft safe Drinking Water Act," In Pakistan the most common water borne disease are Typhoid, Cholera, Hepatitis, Giardiasis, Dysentery and other intestinal disturbances ". Globally 80 % of the children deaths are attributed to water borne diseases.

Nitrate is the upcoming pollutant in drinking water. Main contributors of this ion are Fertilizer use, leachates from refuse dumps; domestic effluents decayed vegetable and animal matter, industrial discharges, and atmospheric wash out.

According to above document a maximum of 10 mg/l of Nitrate, Nitrogen is permissible. Higher level of Nitrate causes Methemoglobinemia, a pathological condition caused by chemical interference with the Oxygen transfer mechanism of the blood. It may be caused in infants by drinking water, high in Nitrate content. Symptoms of this disease are the infant looks blue and has shortness of breath.12.8 % of the samples fall under this category.

In all a total of 47 drinking water samples were collected from Rawalpindi and Islamabad.The criteria of sampling being mostly public places. Extreme care was taken to collect samples in accordance with the instructions of NIH, in the presterlised bottles collected from NIH. The samples were delivered to the Laboratory within 2-3 hours of collection.

Sampling sites included G-9, G-7, G-11, F-11 and airport in Islamabad. While in Rawalpindi we sampled from Railway station, Pirwadhai bus stand, KTM, Cantonment area, medical colleges, civic bodies RMC, WASA, RGH, DHO office, District courts Rawalpindi and Misrial Road,Kalli Tanki, Chah Sultan, Glass Factory and College Road were also covered.