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WATER PURIFICATION: A REVIEW

***Aisha Perveen[1] and Sayeda Shifa Zaidi[2]**

[1]Assistant Professor, Department of Tahaffuzi-Wa-Samaji Tib, School of Unani Medical Education and Research, Jamia Hamdard, New Delhi.

[2]P.G. Scholar, Department of Tahaffuzi-Wa-Samaji Tib, School of Unani Medical Education and Research, Jamia Hamdard, New Delhi.

***Corresponding Author: Dr Aisha Perveen**

Assistant Professor D/o TST ,School of Unani Medical Education and Research Jamia Hamdard.

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ABSTRACT

Water is essential to life. Many health problems such as water born diseases and water related diseases can be caused by using unsafe water; Water is being polluted by the addition of Industrial wastes, urban wastes, pesticides and related pollutant. As the urbanization and industrialization advances, the thrust to get the pure water increased. Water is necessary for many house hold purposes like agriculture, food production, drinking, washing and preparing many household items and many more. There are many ways Pathogen free drinking water is the basic need of healthy life. As there are many ways to purify water on household and industrial level so in this review paper it is attempted to brief the need and effective methods of water purification on small and large scale both.

KEYWORDS: Water, pollution, purification.

INTRODUCTION

Water contains impurities of various kinds that can be natural or man-made. Natural impurities contains many dissolved gases like nitrogen, carbon dioxide while man - made impurities can be dangerous and its major factor is urbanization and industrialization. Many water born and water related diseases such as Poliomyelitis, Viral Hepatitis A, and Hepatitis E etc, can be caused by use of contaminated water.[1] Pure uncontaminated water does not occur in nature. It contains impurities of various kinds –natural and man-made. The natural impurities are not essentially dangerous. These comprise dissolved gasses (e.g. nitrogen, carbon dioxide, hydrogen sulphide, etc. which may be picked up during rainfall) and dissolved minerals (e.g., salts of calcium, magnesium, sodium, etc.) which are natural constituents of water following its contact with soil, and suspended impurities (e.g. clay, silt, sand and mud) and microscopic organisms. These impurities are derived from atmosphere, catchment area and soil. Much of ill health which effects humanity, especially in the developing countries can be due to safe water supply. The absence of clean water and sanitation are major risk factors for ill health.[2][3] There can be no state of positive health and well-being without of safe water. Water is not only a vital environmental factor to all forms of life, but it also a great role to play in socio-economic development of human population. Slow sand filtration emerged as an effective method of treating water for the control of physical, microbiological and chemical contaminants, specially for villages.[4]

We use streams, rivers, ponds as well as ground water reservoirs as source of water. But these sources aren't always clean. Since ancient times, the need of pure water resulted in the development of water purification methods. Initially they didn't know the microbes, but the visual impurities. So mainly they used to purify the water from visual pollutants. Various plants like *Amla* and *Khus, e*tc., were used to purify the water. Studies have found that the nut excrete coagulant chemicals upon soaking which does the trick.[5] As water pollution problem is major health hazard, up to date concentration has been focused on the development of more helpful and effective, cheap, methods for water purification, without any harm to the environment or endangering health.[6] According to unani system of medicine It should be known that water is one of the elements, which is distinguished from the other elements by the fact that it is a part of all foods and drinks, and though it does not nourish, it carries food and rectifies its consistency. Water is not nutritious but water is a substance which helps to liquefy food. But water is a substance which helps to liquefy food and carries it into the vessels and the channels. The help thus rendered by water in completing the process of nutrition is indispensable. Intake of water which is salty causes dryness and weakness in the body; Pruritis develops due to changing of chemistry of blood and loose motions also.[7] Large range of various new chemical compounds and instruments are available these days to purify the water not only from the physical impurities, also from the microscopic pollutants and impurities as well. Apart

from all these above advancement, the old methods described by *Unani* scholars are still working and proved beneficial both at individual level or on small scale and in community level or on large scale.[8]

Water purification

Water purification is the process of cleaning the contaminated water by removing the harmful chemicals, pathogenic microorganisms, suspended solids and gases. The aim is to turn out water fit for a specific purpose. Most of the time water is disinfected for drinking purpose, but water purification may also be planned for variety of purposes such as for medical usage, pharmacological, chemical and industrial usage. Different methods such as water filtration, sedimentation, and distillation, Slow sand filters or biologically active carbon, rapid sand filtration, flocculation, chlorination and the use of ultraviolet light are the methods which are mainly applied for purification. Drinking water quality standards are typically set by governments itself or by international standards. These standards usually include range of minimum and maximum concentrations of bacteria, toxins, or other water polluting agents depending on the proposed purpose of water use.[9] One can not determine the quality of of water by examining it with naked eye. Boiling and other household simple methods like carbon filters are not sufficient for purifying water completely because it can possible that all contaminants may not be removed by these methods. Natural spring water which was earlier considered as safe for all practical purposes in the 19th century but it must now be tested before using. Chemical and microbiological analysis, while very costly, but are the only way to know the proper way of water treatment. Natural purification effects within filter layers and in the subsurface are caused mainly by filtration, sedimentation, precipitation, oxidation-reduction, sorption-desorption, ion-exchange and biodegradation.[10] Easy and simple tools for treating water for household purposes like chlorination, different types of small filters, ultraviolet rays disinfection, and storing it in disinfected and uncontaminated closed containers could save a large number of lives per year. Reducing deaths from waterborne diseases is a major public health goal in developing countries.[2]

Water purification in ancient Times

There were following methods mainly used by ancient people for treatment of water.

Storage

This is natural purification process. Firstly water is drawn out from source and impounded in natural or artificial reservoirs. Storage provides a reserve of water from which further pollution is excluded. As a result of storage, a very considerable amount of purifications takes place. It is done by mean to achieve preparation and sedimentation. Storage especially in Ghada (clay pots) should be done. Storage tank must be open. It may help to purify the water in following ways.

- During stay period settlement of heavy /colloidal particles by their gravity.
- Bacteria present in the water is generally aerobic, they oxidize organic or an ammoniac substances present in water.
- Bacteria sacrifice their life due to loss of nutrition due to oxidizing process and also due to direct exposure to sun rays.

This is the oldest method, but their exact mechanism was not so clear at that time. This is the cheapest process, so can be applied at large scale and even weaker section of people can manage it as easily as it is very cost effective.[1]

Filtration

It is the second stage in the purification of water. Filtration by cloths was the popular methods to exclude out the earthy and other micro pollutants from the water. Clothes having different pore sizes were in use to filter the water. This method was very cheap, easy and popular among weaker section of community.[1]

Boiling

It is the satisfactory method of purifying for household purposes; still in use popularly and effectively. To be effective, the water must be brought to a "rolling boil" for 10 to 15 minutes.

Boiling makes water thin and removes temporary hardness (produced by cold) by driving off carbon dioxide and precipitating the calcium carbonate; the taste of water is altered, but this is harmless. Thus the particles of water become well rarefied till it becomes thin in consistency.[1][1] Thus, it is possible for the heavy earthy particles mixed in water to be separated from it. They sink down in water and are thus separated from it in the form of sediment. There remains only water which is nearer to the simple water.

Other than these three major methods vessel method, churning and percolation were also used to purify contaminated water.

Large Scale Purification Of water

The components of a characteristic water decontamination system comprise one or more of the following measures;

1. Storage.
2. Filtration.
3. Disinfection.

Slow sand or biological filters

They are generally accepted as the standard method of water purification. Slow sand filters were first used for water treatment in 1804 in Scotland and subsequently in London. During the 19th century their use spread throughout the world.[1] Slow sand filtration in is very useful in the removal of turbidity and harmful or

pathogenic microorganisms such as enteroviruses, Campylobacter, Cryptosporidium, E. coli and Giardia.[4]

History of slow sand filters

The first acknowledged use of sand filter to purify the water supply was in 1804, After two decades method was advanced by engineers working for private water companies, and in the year 1929 first purified water supply on the earth installed by engineer James Simpson for the Chelsea Waterworks Company in London. This installation provided filtered water for every resident of the area, and the network design was widely copied throughout the United Kingdom in the ensuing decades. The practice of water treatment soon became mainstream, and the virtues of the system were made starkly apparent after the investigations of the physician John Snow during the 1854 Broad Street cholera outbreak. Snow was sceptical of the then-dominant miasma theory that stated that diseases were caused by noxious "bad airs". Although the germ theory of disease had not yet been developed, Snow's observations led him to discount the prevailing theory. His 1855 essay On the Mode of Communication of Cholera conclusively demonstrated the role of the water supply in spreading the cholera epidemic in Soho, with the use of a dot distribution map and statistical proof to illustrate the connection between the quality of the water source and cholera cases. His data convinced the local council to disable the water pump, which promptly ended the outbreak.[11] [1] [9]

The Metropolis Water Act set up the ruling of the water supply corporations in London, including minimum principles of water quality for the first time.[11]

Elements of a slow sand filter

Essentially these consist of

- Supernatant (raw) water.
- A bed of graded sand.
- An under drainage system.
- A system of filter control valves.

Supernatant water

The supernatant water above the sand bed, whose depth vary from 1 to 1.5 metre, serves two important purposes:

- It promote the downward flow of water through the sand bed.
- It provides a constant head of water so as to overcome the resistance over the filter bed and thereby provides waiting period of some hours (3-12 hours, depending upon the filtration velocity) for the raw water to undergo partial purification by sedimentation, oxidation and particle agglomeration.[1]

Sand bed

The most important part of the filter is the sand bed, the thickness of sand bed is about 1metre. the sand grains are carefully chosen so that they are preferably rounded and have an effective diameter between 0.2 and 0.3 mm.[1]

Vital layer

At the surface of the sand, an active layer of schmutzdecke, which is made up of biological matter, breaks down the microorganisms and organic matter contaminants in the raw water.[12] When filter is newly laid, it acts merely as a mechanical strainer, and cannot truly be considered as “biological”. After that the surface of the sand bed gets covered with a slimy growth known as vital layer, biological layer or zoological layer also known as ‘schmutzdecke’,. Until the vital layer is fully formed, the first few days filtrate is usually run to waste.[1] [11]

Under- drainage system

At the bottom of the filter bed is under- drainage system. It consist of porous or perforated pipes which serve dual purpose of providing an outlet for filtered water, and supporting the filter medium above.[1]

Filter control

The filter is equipped with certain valves and devices which are incorporated in the outlet -pipe system. The purpose of these devices is to maintain a constant rate of filtration. While many municipal water treatment works will have 12 or more beds in use at any one time, while small groups or households may only have 1 or 2 filter beds. In the bottom of each bed is a chain of herringbone drains use up that are enclosed with a cover of pebbles which in turn is covered with coarse gravel. Further layers of sand are placed on top followed by a thick layer of fine sand. The entire depth of filter material may be more than 1m, the most part of it will be fine sand material. On top of the sand bed a supernatant layer of unpurified water.

Advantages

- As they do not entail electrical energy.
- Require very small or no mechanical power.
- They do not require any chemicals or replaceable parts, and they require minimal operator training and only periodic maintenance, they are often an appropriate technology for poor and isolated areas.
- Simple to construct.
- Slow sand filters, due to their simple design, may be created DIY. DIY-slow sand filters have been used in Afghanistan and other countries to aid the poor.
- According to the World Health Organization, "Under suitable circumstances, slow sand filtration may be not only the cheapest and simplest but also the most efficient method of water treatment.[1]

Rapid sand or mechanical filters

History

In 1885, the first rapid sand filters were installed in the USA.[1]

Types

These are of two types

a) Gravity Type
b) Pressure Type

Steps involve in purification of water

The initial steps of clarification is same as for slow sand filter. The filter bed is a watertight rectangular chamber with a surface area of about $90m^2$.[9]

a) Coagulation
b) Rapid Mixing
c) Flocculation
d) Sedimentation
e) Filtration.[1]

Advantages

- Filter directly raw water
- No previous storage of water is required
- Filter bed occupy less space
- Filtration rate is rapid 40-50 times that of slow sand filter.[1]

Disinfection and Sterlization

- Sterilization of water is the method of water purification that kill or destroys, removes or deactivates the all form of microorganisms in the water. It prevents the spread of diseases which can occur through usage of impure water.[13]
- Firm obedience to current disinfection and sterilization guidelines is essential to prevent patient infections and exposures to infectious agents.[14]
- Chemical methods such as Ozone sterilization of water, Hydrogen peroxide sterilization, Chlorination sterilization etc are used.
- Physical methods such as boiling, UV sterilization are used.

Chlorination

This method of water purification was came in practice in the early 1900's, diseases which can spread through consumption of contaminated water have been virtually eliminated. These dramatic reductions of cholera and typhoid were achieved in the first half of this century well before antibiotics and immunizations were even invented (United States Environmental Protection Agency. "Fact Sheet on Water Chlorination", 1992).[15]

Points to remember in chlorination

- Chlorine solutions lose strength while standing or when exposed to air or sunlight. Make fresh solutions frequently to maintain the necessary residual.
- Maintain a free chlorine residual of 0.3-0.5 mg/l after a 10-minute contact time. Measure the residual frequently.
- If the chlorine dosage is improved to meet greater demand, do not reduce it.
- Find and abolish the source of contamination to avoid continuous chlorination. Use that available water source which does not need disinfection.
- Keep records of pertinent information concerning the chlorination system.
- Chlorination of Drinking Water

For both household and domestic purpose bulk amount of chlorine is produced and it is also used in disinfecting swimming pool.[16]

Testing water for biological quality

The biological quality of drinking water is determined by tests for coliform group bacteria. These organisms are found in the intestinal tract of warm-blooded animals and in the soil. Their presence in water indicates pathogenic contamination, but they are not considered to be pathogens. The standard for coliform bacteria in drinking water is "less than 1 coliform colony per 100 milliliters of sample" (< 1/ 100ml).Public water systems are required to test regularly for coliform bacteria. Private system testing is done at the owner's discretion. Drinking water from a private system should be tested for biological quality at least once each year, usually in the spring. Testing is also recommended following repair or improvements in the well. Coliform presence in a water sample does not necessarily mean that the water is hazardous to drink. The test is a screening technique, and a positive result (more than 1 colony per 100 ml water sample) means the water should be retested. The retested sample should be analyzed for fecal coliform organisms. A high positive test result, however, indicates substantial contamination requiring prompt action. Such water should not be consumed until the source of contamination is determined and the water purified. A testing laboratory provides specific sampling instructions and containers. The sampling protocol includes the following.

- Run cold water for a few minutes (15 minutes) to clear the lines;
- Upon collecting the sample, immediately cap bottle and place in a chilled container if delivery to lab exceeds 1 hour (never exceed 30 hours). Many laboratories do not accept samples on Friday due to time limits.
- Use sterile sample container and handle only the outside of container and cap.

Chlorine treatment

It combines with contaminants dissolved in water. These components use the chlorine and consist of the chlorine demand of the treatment system. It is important to add sufficient chlorine to the water to meet the chlorine demand and provide residual disinfection. The chlorine that does not combine with other components in the water is free (residual) chlorine, and the breakpoint is the point at which free chlorine is available for continuous disinfection. An ideal system supplies free chlorine at a concentration of 0.3-0.5 mg/l. Simple test kits, most commonly the DPD colorimetric test kit (so called because diethyl phenylene diamine produces the color reaction), are available for testing breakpoint and chlorine residual in private systems. The kit must test free chlorine, not total chlorine.

Supercholrination

Superchlorination include the adding up of large doses of chlorine to the water, and removal of surplus of chlorine after disinfection, this method is appropriate to heavily polluted waters whose quality vary very much.[1]

Contact time with microorganisms

The contact time in chlorination is that period between the introduction of the disinfectant and when the water is used. A long interaction between chlorine and the microorganisms results in an effective disinfection process. The contact time varies with chlorine concentration, the type of pathogens present, pH, and temperature of the water.[1]

Chlorination levels

If a system does not agree to sufficient contact time with normal dosages of chlorine, superchlorination may be important and necessary. Superchlorination provides a chlorine residual of 3.0-5.0 mg/l, 10 times the recommended minimum breakpoint chlorine concentration. Retention time for superchlorination is approximately 5 minutes. Activated carbon filtration removes the high chlorine residual.[1]

Purification of Water on a Small Scale

Household Purification of Water

- Boiling
- Chemical disinfection
  - Bleaching powder
  - Chlorine solutions
  - High test hypochloride
  - Chlorine tablets
  - Iodine
  - Potassium permanganate
- Filtration: Water can be purified on a small scale by filtering through ceramic filters such as Pasteur Chamberland Filter, Berkafeld Filter and Katadyn Filter.[9][1]

Disinfection of Wells

Steps Involved

- Find the volume of water in the well
- Find the amount of bleaching powder required for disinfection (Roughly 2.5 g of good quality bleaching powder would be required to disinfect 1000 litres of water.
- Dissolve bleaching powder in water
- Delivery of chlorine solution into the well
- Contact period of 1 hour
- Orthotolidine arsenite test.[1]

CONCLUSION

Safe and Uncontaminated water is the key to healthy life. Many water related and water born diseases like typhoid, paratyphoid and bacillary dysentery etc., can be prevented by using of safe and uncontaminated water. So there is a strong need of knowing the cheap and safer ways to purify water.

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