



WATER POLLUTION AND ITS PURIFICATION MEASURES W.R.T. ANCIENT AND MODERN SCIENCES

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ABSTRACT

Introduction: Water is a unique amenity found on earth and pure water is a basic necessity for all animals. Present work is done to study causes and effects of water pollution and its purification measures with reference to ancient and modern Sciences. **Aim & Objective:** aim is to study water pollution and its purification measures w.r.t ancient and modern science. **Material & Method:** *Ayurvedic* texts and Modern textbooks is the material. Methodology is study and compare both techniques. **Literature review:** this includes definition of pure water, polluted water by ancient and modern point of view. Blemishes of polluted water, diseases caused due to polluted water, and purification methods of polluted water by both ancient and modern point of view.

Observation: it gives idea about different methods of purification of water according to different *ayurvedic* texts and list of chemical components and their safest quantity in drinking water. **Discussion:** comparison of above information is done here. **Conclusion:** Though the pollutants were limited in ancient times, some of the purification methods described by *Acharyas* are still helpful. With the help of these simple techniques purest form of water can be provided to commonest people easily.

KEYWORDS: Water pollution, *Jala Pradushana*, water purification, *Jala Prasadana*.

INTRODUCTION

Water is a unique amenity found on earth and pure water is a basic necessity for all animals. However today with various contaminations, water resources are getting polluted which is affecting not only human health but also disturbing the natural balance. Water resources are contaminated by sewage material, Microbes, agrochemicals like fertilizer, pesticides,

herbicides, Industrial wastes like toxic chemicals, metallic salts, radioactive materials, excessive heat, Household chemicals like detergents, plastics, etc. Many of these materials seeps through the ground and contaminate the important natural water source i.e. Groundwater. As these groundwater sources are connected to the surface water like rivers and lakes; ultimately all these reservoirs get contaminated. Water contaminated with chemicals, increased amount of minerals and radioactive materials leads to bioaccumulation of these elements in living body; which leads to hazardous conditions like Anemia, cardiovascular diseases, cancers, neurological disorders, etc. Water polluted with petrochemical harms the aquatic plants and animals. In today's era majority of pollution is man-made hence efforts should be made to control and protect such natural sources.

Ayurveda explains that the consumable water should be free from any taste, odor or impurities. Whereas water covered with weed/algae, not exposed to sunlight and having odor should not be consumed. In Ancient books of *Ayurveda*, various methods are described to clean such water to make it consumable. Present work is done to study causes and effects of water pollution and its purification measures with reference to ancient and modern Sciences.

AIM: To study water pollution and its purification measures w.r.t ancient and modern science.

OBJECTIVE

- 1) To study causes of water pollution and its effects.
- 2) To study ancient and modern measures to purify polluted water.

MATERIAL AND METHOD

Material

- 1) Ayurvedic texts like Charak Samhita, Sushruta Samhita and Astanga Samgraha.
- 2) Modern textbooks.

METHODOLOGY

Study is done in following stages

Stage 1: Literature about water pollution and its purification measures are collected from ayurvedic texts and the other available sources like modern textbooks, internet and research articles etc.

Stage 2: Comparison of both the methods.

Stage 3: Conclusion is drawn.

Literature Review

- **Definition of pure water according to *Ayurveda***

Water which is odorless, does not having specific taste, which quenches thirst, free from impurities, pleasant for intake is said to be Pure water.^[1]

- **Polluted water according to *Ayurveda***

Water which is covered over with slush, algae, weed, grass, leaves of lotus etc., which is not exposed to rays of sun, moon and air, which is having color, odor and taste very predominantly, should be considered as polluted water. This is called '*Vyapanna Jala*'.^[2]

According to other opinion, water which is contaminated with the urine, excreta and decomposed dead body of insects and snakes; which is having a network of weed and rubbish, thick with presence of silt, plants growing in slit, algae, rootless plants; leaves covering the entire surface, sunlight and air not reaching the water at all; water full of insect, worms etc; discolored, dirty; of bad taste and foul smell, that which causes chills in the teeth being very cold, water which is polluted with poisonous matter from spiders and other insects.^[3]

- **Blemishes of '*Vyapanna Jala*'^[4]**

Blemishes of water which makes it '*Vyapanna*' according to *Ayurveda* are as follows: Blemishes will be of 6 kinds – roughness, slimyness, warmth, producing tingling of the teeth are blemishes of touch, presence of slush, sand, algae and many colors are blemishes of sight; prominence of taste is the blemishes of taste; unpleasant odor is blemish of smell; Producing thirst, feeling of heaviness, abdominal pain, more elimination of *kapha* from the mouth etc. are blemishes of potency; getting digested after a long time or causing constipation are blemishes of tastes after digestion.

These blemishes are not present in pure water.

- **Purification of '*Vyapanna Jala*'**

Purification of '*Vyapanna Jala*' is done by following methods in *Ayurveda* –

According to *Sushruta*^[5] - boiling over fire, heating by exposing to sunrays, immersing heated iron balls, sand or stone into water are methods to purify contaminated water. Putting

flowers such as *naga champaka*, *utpala*, etc into water and allowing these for some time to stay in it to remove bad smell and impart good smell.

According to *Astanga Sangraha*^[6] – polluted water should be filtered through thick cloth to remove insects and worms, heated by fire, exposure to sunlight or by immersing red – hot iron balls into it; it should be made clear by putting into it *parnimula*, tubes of lotus plant, pearls, seeds of *kataka*, algae, thick cloth or *gomedaka*; its bad smell being removed by putting it into the flowers of *Patala*, *Karavira* and such other sweet smelling one.

- **Clearing turbidity of water (*Jala Prasadana*)**^[7]

Methods of clearing the turbidity of polluted water are seven – such as by the use of *kataka* (adding the paste of *kataka* nut to water), *gomedaka* (gem), *bias granthi* (rhizome of lotus), *saivala mula* (root of algae) – these are immersed in water; *vastra* (cloth, filtering through it), *Mukta* (Pearl), *mani* (Crystals of rocks) or gems by immersing them into water.

- **Effect of consumption of ‘*Vyapanna Jala*’**

‘*Vyapanna Jala*’ (Polluted water) produces aggravation of the doshas and are unsuitable for health; he who drinks polluted water without purifying it, gets affected quickly by dreaded diseases like dropsy, anemia, skin diseases, improper digestion, dyspnea, cough, nasal catarrh, abdominal pain, tumors of the abdomen, abdominal enlargement or any others.^[8]

According to other *Acharya* – If this ‘*Dusta Jala*’ is used for drinking or bathing; they will produce thirst, distension and enlargement of the abdomen, fever, cough, weak digestive capacity, ophthalmia, itching and boils on the skin. Hence such contaminated water should be rejected.^[9]

- **Definition of pure water according to Modern**

Water that is free from pathogenic agents, free from chemical substances, free from color and odor, usable for domestic purposes is said to be safe and wholesome water.

Water is claimed to be contaminated/ polluted when it does not fulfill the above criteria.^[10]

- **Types of impurities found in contaminated water**

Impurities found are mostly of 2 types.

- 1) Natural: these are not essentially dangerous. Comprises of dissolved gases (eg. Nitrogen, carbon dioxide etc.) and dissolved minerals (eg. Calcium, magnesium, sodium).

- 2) Man-made: this is serious type of pollution caused due to human activity. the sources of pollution resulting from these are –
- a) Sewage – which contain decomposable organic matter and pathogenic agents.
 - b) Industrial and trade wastes – contains toxic agents ranging from metal salts to complex synthetic organic channels.
 - c) Agriculture pollutants – fertilizers and pesticides.
 - d) Physical pollutants – heat and radioactive substances.

- **Water related diseases**

Human health may get affected by indigestion of contaminated water directly or indirectly through food. Biological or water borne diseases i.e. diarrhea is caused due to presence of viral, protozoal, bacterial, helminthic agents etc. Minerals like Sodium causes Cardiovascular diseases. Pesticides like DDT causes cancer and chromosomal changes. Many other minerals like mercury, asbestos, fluorides, nitrates and lead are found to be carcinogenic and causing neurological disorders by bioaccumulation. Petrochemicals, oils forms a layer over water surface thus decreasing the ability of photosynthesis of aquatic plants. Phosphorus and nitrogen compounds promotes growth of algae which decreases the amount of dissolved oxygen in water. This leads to decomposition of plant materials. This changes CO₂ concentration of water leading to changes in PH, oxygen levels and temperature. Thus physicochemical properties of water are hampered. Such water is poisonous to drink.

- **Poisoning of water^[11]**

Now a days Percentage of Chemical pollutants of diverse nature derived from agricultural wastes are found increasing in public water supplies. These pollutants include detergent solvents, cynides, heavy metals, minerals and organic acids, nitrogenous substances, bleaching agents, dyes, pigments, sulfides, ammonia, toxic and biocidal organic compounds of great variety. These pollutants may affect man's health not only directly but also indirectly by accumulating in aquatic life (eg. Fish) used as human food. Hence the present concern about chemical pollutant is about their long term effects on human body as it may lead to various Metabolic and neurological disorders. Further some of new pollutants are not easily removed by conventional water treatment or purification method. These increases severity of the problem.

- **Water pollution law**^[12]

To protect the water from being contaminated, the Indian parliament in 1974 passed the Water (Prevention and Control of pollution) Act. This act seeks to provide legal deterrent against the spread of water pollution.

- **Purification of water**

Purpose of purification of water is to produce safe and wholesome water. Method of treatment depends on nature of raw water.

It may be considered under two headings:

- 1) **Purification of water on large scale**^[13]

This system comprises one or more of following measures – storage, filtration, disinfection. They are explained as follows –

- a) **Storage:** water is drawn out from the source and impounded in natural or artificial reservoirs. As a result of storage considerable amount of purification takes place. This is natural purification. It is found that when river water is stored the total bacterial count drop by as much as 90% for the first 5-7 days. This is the greatest benefit of storage. Optimum period of storage is 10-14 days. If water is stored for longer period; there is likelihood of development of algae etc which impart bad smell and color to water.
 - b) **Filtration:** Filtration is second stage in the purification of water, and quite important stage because 98-99% of the bacteria are removed by filtration, apart from other impurities. 2 types of filters are in use, the ‘biological’ or slow sand filters and the Rapid sand filters or ‘Mechanical’ filters.
 - c) **Disinfection:** In water purification, the term disinfection is synonymous with chlorination mainly.
1. **Chlorination:** It is used as a supplement with sand filtration. Chlorine kills bacteria but has no effect on spores and certain viruses except in high doses. Apart from germicidal effect; chlorine oxidizes iron, manganese, hydrogen sulfide; destroys some taste and odor producing bacteria, controls algae and slime organism and aids coagulation.
 2. **Ozonation:** Ozon is a powerful oxidant and has many uses in water treatment, including oxidation of organic chemicals. It can be used as primary disinfectant.
 3. **Membrane processes:** The membrane processes which are most significance in water treatment are reverse osmosis, ultrafiltration, microfiltration, nanofiltration. These

processes have traditionally been applied to the production of water for industrial or pharmaceutical applications, but are now being applied to treatment of drinking water.

2) Purification of water on small scale

a) **Household purification of water:** These methods are generally available for purifying water on an individual or domestic scale. These methods can be used singly or in combination.

1. **Boiling:** it is satisfactory method of purifying water for household purposes. To be effective, the water must be brought to a 'Rolling boil' for 10 to 20 mins.
 2. **Chemical disinfectant:** Bleaching powder, Chlorine solution, high test hypochlorite or perchloron. Chlorine tablets, Iodine, Potassium permanganate etc. are used as chemical disinfectant.
 3. **Filtration:** Water can be purified on a small scale by filtering through ceramic filters such as Pasteur Chamberland filter, Berkefeld filter and 'Katadyn' filter.
 4. **Ultra violet Irradiation:** UV irradiation is effective against most microorganisms known to contaminate water supplies like bacteria, yeast, viruses, fungi, algae, protozoa etc.
 5. **Multi-stage reverse osmosis purification of water:** Multi-stage reverse osmosis process is used to make water both chemically and microbiologically potable by reducing the total dissolved solids, hardness, heavy metals, disease causing bacteria, viruses, protozoa, cysts.
- b) **Disinfection of wells:** Wells are the main source of water supply in the rural area. The need often arises to disinfect them, sometimes on a mass scale, during epidemics. The most effective and cheapest method of disinfecting wells is by bleaching powder.

OBSERVATION

1) Table no. 1: Methods of Purification of water According to different Ayurvedic texts.

No.	<i>Astanga Samgraha</i>	<i>Sushruta Samhita</i>
1.	<i>Paristravana</i>	<i>Marjana</i>
2.	<i>Nirvapana</i>	<i>Prasadana</i>
3.	<i>Prasadana</i>	
4.	<i>Durgandhanashana</i>	

2) Table no. 2: Inorganic chemicals of health significance in drinking water.^[14]

No.	Constituents	Recommended maximum limit of concentration ($\mu\text{g/litre}$)
1.	Antimony	20
2.	Arsenic	10
3.	Barium	700
4.	Boron	2,400
5.	Cadmium	0.3
6.	Chromium	50
7.	Copper	2,000
8.	Fluoride	1,500
9.	Lead	10
10.	Manganese	400
11.	Mercury	6
12.	Molybdenum	70
13.	Nickel	70
14.	Nitrate	50,000
15.	Nitrite	3,000
16.	Selenium	40

3) Table no. 3: Guideline values for health related organic constituents.^[15]

No.	Organic constituents	Upper limit of concentration ($\mu\text{g/litre}$)
1.	Chlorinated alkanes	
2.	1) Carbon tetrachloride	2
3.	2) Dichloromethane	20
4.	Chlorinated ethenes	
5.	1) Vinyl chloride	55
6.	2) 1.1- dichloroethane	30
7.	3) 1.2- dichloroethane	50
8.	Aromatic hydrocarbons	
9.	1) Benzene	10
10.	2) Toluene	700
11.	3) Xylene	500
12.	4) Ethylbenzene	300
13.	5) Styrene	20
14.	6) Benzolalpyrene	0.7

4) Table no. 4: Guideline values for certain pesticides.^[16]

No.	Pesticides	Upper limit of concentration ($\mu\text{g/litre}$)
1.	Aldrin	0.03
2.	Chlordane	0.2
3.	DDT	2
4.	2,4 -D	30
5.	Heptachlor and heptachlor epoxide	0.03
6.	Hexachlorobenzene	1
7.	Lindane	2
8.	Methoxychlor	20
9.	Pentachlorophenol	9

DISCUSSION**1) Definition of pure water**

Qualities of pure water explained by *Ayurveda* thousand years ago, are still relevant and acceptable in modern world.

2) Definition of polluted water

Definition given by *Acharya* for polluted water indicates the contraindication to consume such water whose physicochemical properties are changed. *Acharyas* has explained blemishes, which were majorly based on the observations made over the years.

3) Purification methods of polluted water

Ancient methods of purification are slightly different according to different *Acharya*. (Ref. table no.1). These methods are useful if physicochemical properties of water are changed.

For today's large scale needs huge purification plants are developed With the help of advancements in science. Hence the purification methods are divided into 2 major categories- large scale purification, small scale purification which is done in stages. However These methods have there limitations as some harmful chemicals are still found in water after purification process.

4) Poisoning of water

In ancient era, poisoning water sources was used as a war strategy to decrease the power of opponents. Today because of many man-made mistakes water reservoirs are getting polluted; which is affecting each and every community living on the earth. Change in PH and mineral contents of water is leading to many health disorders since childhood. Water contaminated with heavy metals like lead and mercury is causing accumulation of these materials in body;

known as bioaccumulation. These is having effect like slow poisoning by affecting in long-term; precipitating to neurological and chromosomal disorders. Higher quantity of minerals and radioactive materials emitted from various industries into the water has been proven to be causing different carcinomas. Petrochemicals, overuse of pesticides and fertilizers are alarmingly harming the aquatic environment. Excessive use of plastic and Treatment of sewage water is also one of the major area of concern for modern civilization. Mixing of such water with drinking water is main reason for various water borne diseases; especially in developing countries and crowded cities. List of such components and their safest quantity in water is given in table no.2 and table no.3 and table no.4.

CONCLUSION

The definition given by WHO for pure water is strikingly similar to the definition given by Acharyas. This shows that requirement of pure water is still the same. In present era, ways of contaminations are increased compared to the ancient world. Modern civilization and industrialization is harming natural sources of water leading to increased requirement of effective purification methods. As the variety of contaminations increased, so the hazardous effects of such pollutants on living objects increased. For today's large scale needs huge purification plants are developed.

Though the pollutants were limited in ancient times, some of the purification methods described by *Acharyas* are still helpful. Boiling water is the safest method used since ages. Apart from this exposure to sunlight, filtration with cloth, precipitating impurities with gems/lotus roots and decreasing foul odour with use of flowers / paste of herbs with pleasant smell are advised. Though these methods have some limitations; they can be proved as very useful in the remote villages where large purification techniques cannot be established. With the help of these simple techniques purest form of water can be provided to commonest people easily.

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