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Research

ECO-FRIENDLY WATER PURIFICATION USING TRADITIONAL METHODS

Sai Manjusha Thummala[1*], Amrutha Sravanika Thota[2], Syamala Yarramsetti[3], Dr. Pisipati Aparna[4]

[1,2,3] B. Pharmacy Students, [4]Professor*

NRI College of Pharmacy, Pothavarappadu, Agiripalli, Eluru District, Andhra Pradesh, India.

*Corresponding author: Sai Manjusha Thummala
Email: saimanjushathummala@gmail.com

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Abstract

Water purification using locally available natural resources offers an eco-friendly, sustainable, and cost-effective solution to improve drinking water quality. Traditional methods employing seeds and medicinal plants have been widely recognized for their effectiveness in coagulation, antimicrobial action, and removal of impurities. Moringa seeds contain water-soluble proteins that act as natural coagulants, effectively reducing turbidity and suspended particles. Similarly, Strychnos potatorum (Nirmali seeds) possess active compounds that clarify water and enhance sedimentation. Tulasi (Ocimum sanctum), known for its antimicrobial and antioxidant properties, helps in reducing microbial load, while neem (Azadirachta indica) exhibits strong antibacterial and antifungal activity, making water safer for consumption. The combined use of these natural agents not only minimizes chemical dependency but also ensures accessibility in rural and resource-limited areas. Thus, water purification through moringa, Nirmali seeds, Tulasi, and neem represents a promising, eco-friendly approach to address safe drinking water challenges.

Keywords: Water purification, Eco-friendly methods , Moringa seeds, Nirmali seeds, Tulasi, Neem.

INTRODUCTION:

Life depends on water as a vital resource. It is essential for socio-economic development, food production and energy efficiency, healthy ecosystems, and human survival, as it forms the basis of sustainable development. Public health ties are essential to water purification, which involves the removal of harmful microorganisms and chemicals from the water supply chain in order to make it safe for consumption.

The occurrence of diarrhea and other diseases caused by contaminated water is responsible for the deaths of approximately 525,000 children under five every year. Waterborne diseases are prevented by water treatment

processes that remove turbidity and eliminate pathogens, including bacteria, viruses, and microorganisms. The majority of communities rely on natural water sources, whether it is surface or groundwater, to clean up and maintain their drinking water. Underground aquifers, creeks and streams or rivers are also resources such as lakes, rivers . Saltwater seas and ocean are also sources of drinking water as well, used for household purposes. To ensure water quality, the government sets the maximum acceptable levels of contaminants. Hence, water purification is necessary to prevent illness and maintain the health of the community.'

Most industrialized countries have successfully resolved the problem, leading to a majority of their population having access to clean drinking water. The primary factors contributing to this are governments, strict regulations and regular monitoring of sewage management, providing clean drinking water through centralized surveillance, hygiene measures (including the use/supply of sanitation facilities). In many countries with limited resources, this remains a major issue due to high population growth rates, inadequate economic development, and insufficient political action.

Developing country rural areas pose the greatest challenges. The primary source of water for transportation is still surface water that is polluted, such as ponds and rivers. Water is frequently polluted by coliform bacteria and viral pathogens. Factors including poor hygiene habits, a lack of proper sanitation facilities, and severe flooding during rainy seasons exacerbate the issue. Centralised and processed water contamination is very likely [(1)].

Furthermore, in certain impoverished nations, there is a thriving market for tap water that is believed to be safe for drinking. Nigerian work has demonstrated that these sachet contents are frequently polluted due to improper packaging and storage, as well as inadequate hygiene practices during processing. The occurrence of diarrhea and potentially life-threatening complications like dehydration and acute kidney injury are linked to these factors [(2)]. Lead and other heavy metals, arsenic, and organophosphate levels are among the non-infectious contaminants that can be present in drinking water.

Evidence of the harmful effects of microbial pathogens in water has been established since the early days of epidemiological studies conducted by physician John Snow in the 1800s. According to the World Health Organization, 88% of all diarrheal diseases are caused by unclean drinking water and inadequate sanitation facilities. The root cause of gastrointestinal disease in many countries is often traceable to microbiologically contaminated water, with diarrhea and other harmful effects, including acute kidney injury. Those who consume polluted or contaminated water sources may be at risk of developing sickness due to chemical or microbiological hazards that must be treated before drinking water [(3)].

Chemical and physical properties of water:

A polar inorganic substance called H2O is liquid that exhibits tastelessness, smell lessness and nearly colorlessness with a slight blue hue under normal conditions. The universal solvent hydrogen chalcogenide is the easiest and most easily dissolvable, as it can dissolve a wide range of substances, including many salts, sugar syrups (including water), simple alcohols or proteins, polycrystalline cellulose, DNA, oxygen, and carbon dioxide.

Due to the higher electronegativity of oxygen atoms, which results in a slight negative charge on its oxygen counterpart, while hydrogen atomic particles are slightly positive, making the water molecule polar and electrically dipole. Furthermore, the composition of water molecules includes one oxygen atom and two hydrogen atomic components connected by covalent bonds.

Sources of water:

Our primary sources of water for consumption, including drinking water and washing, agriculture, and industry are derived from surface water as well as groundwater collected from rain and snow. Agriculture, industrial processes, food, and energy production all require water as a vital component of life.

1. Surface Water

Water that lies in a river, lake, or freshwater wetland is known as surface water. The natural process of refilling and removing it is carried out through precipitation, ocean discharge, evapotranspiration, groundwater recharge, and water evaporation. The total amount of water available and the proportions of lost water in a system are dependent on several factors, including precipitation.

The amount of surface water is largely determined by precipitation..

By constructing reservoirs or draining wetland, humans can limit the storage capacity of surface water systems. The use of vast surface water reservoirs is a viable option for producing hydroelectric power, controlling river flows and providing recreational drinking water as well as agricultural, municipal und industrial services.

2. Ground water:

An aquifer is essentially an underground layer of rock that contains water.' Rocks that are permeabilized with water allow liquids and gases to pass through them. Groundwater is found in the form of aquifers. Groundwater tends to be cleaner than surface water. Resupply or recharge is achieved by precipitation that seeps through the soil and streams, as well as other surface water bodies like lakes and wetlands [(4)].

Types of water.

Different chemical, physical, and biological characteristics are used to classify water.

1. Potable water:

Water that is safe for human consumption and has been properly treated can be considered potable water or drinking water. This definition does not require any additional explanations. This product is clear, pure, and free of any bad taste or odour.

2. Fresh water:

Natural fresh water is found both at the surface (ice), in wetland, ponds, lakes and streams as well and underground (ground) water in aquifers. Low concentrations of dissolved salt and solids are typical.

3. Salt water:

Seawater is a component of the Earth's oceans and seas. See also seawater. The dissolved salt content of this substance is roughly 3.5%.me.

4. Brackish water:

The salt content of brackish water is not well-defined, with a range between 0.5 and 30 grams of salt per litre.

5. Hard water:

Hard water is rich in minerals, especially magnesium and calcium salts. This water is also called calcareous water.

6. Soft water:

Soft water has a low concentration of dissolved salts. Water with calcium carbonate levels below 50 mg/litre may be the description.

7. Distilled water:

The molecules of H2O are present in distilled water after being purified / cleaned.

8. Waste water:

The quality of water that has been impacted by human activity is known as waste water. The FAO has stated that the water's quality, quantity, or availability does not make it any more relevant for its intended use or production.

9. Black wate:

Faeces or urine contamination is present in black water, which is found in the different types of used water

10. Grey water:

Grey water is domestic wastewater. Unlike black water, it contains organic and inorganic matter, as well as microorganisms, and has lower levels of nitrogen and phosphorous. Grey water is named due to its haziness and its location between potable freshwater and wastewater.

11. Raw water:

Water that has not been treated is known as raw water. Surface water and groundwater are found in their natural sources and reservoirs [5].

Sources and Types of Contaminants:

The classification of water contaminants can be based on their chemical composition and source. Among the primary sources are:

- Factories emit heavy metals (e.g, lead, mercury and cadmium), solvents, and POPs from industrial discharges; these pollutants pollute nearby water bodies.
- Aquatic ecosystems are negatively affected by nutrients like fertilizers, pesticides, and herbicide.
- The sewage system in urban areas receives household, pharmaceutical, and personal care products, which are then transported to natural water sources;

The global environmental transport of pollutants is mirrored by the deposition of airborne pollutants, such as PAHs and mercury, into water bodies through precipitation.

- Pollution is a result of environmental factors like volcanic eruptions, wildfires and dust storms; the natural weathering of heavy metals from soil and rocks (heavy metal cans), and the decomposition of organic matter (organic matter) [6,7].

Water uses:

1.Domestic use:

Domestic uses, including cooking, laundry, toilet flushing, drinking water, bathing and gardening, are responsible for 8% of global water use.

Approximately 50 gallons of domestic water is required, not including water for gardening. L per day, on an approximation. Drinking water, which can be consumed or used without risk of harm, is the term used to describe water that is considered safe for drinking or using. The majority of developed countries provide drinking water for domestic, commercial, or industrial uses, but only a small amount is utilized for food preparation.

2. Agricultural use:

Over half of all water utilized for household reasons is used for agricultural purposes. According to estimates, irrigation is responsible for 70% of the world's water consumption, and unsustainable droughts account for 15%-35% of irrigation withdrawals.

3. Industrial use:

Hydroelectric dams, manufacturing plants (thermoelectric power plants), ore and oil refineries, and industrial water use are significant uses of the water from an environmental perspective. These processes can use water as a cooling agent, solvent, and chemical reagents. Water blasting, water jet cutters, and high-pressure water guns frequently use pressurized water as industrial water. This is another application. In addition to being safe and effective, these uses do not pose any environmental risks. Industrial water consumption is a small fraction of the total water consumed, and this can be used to cool machinery caused by overheating. Many industrial processes, including oil refining, chemical plants, thermoelectric power production, and natural gas extraction from shale rock, require the use of water. Pollution results from these processes as a result of untreated water discharge (chemical pollution) and increased water temperature (thermal pollution). This is known as solute discharge. For the above-described industrial water use, clean water is often required, and different purification techniques are used for both supply and outflow [(4)].

WATER TREATMENT:

After being mixed, coagulated, and flocculated to purify the water supply of the treatment plant, it is transported from inlets in the existing water source. The water is fed into the mains for storage or distribution after being treated.

WATER PURIFICATION METHODS:

The methods of water purification are following as:

- **Natural Methods**
  - Aeration
  - Sedimentation
  - Sunlight
  - Dilution
  - Oxidation
  - Plants and Animals (Aquatic)
- **Artificial Methods**

It consists of two methods:

- Purification of water on a Large Scale .
- Purification of water on a small scale.

PURIFICATION METHODS:

Boiling Water:

Boiling water is the least expensive and most secure way to purify water, as it can be done at home without any microbiological risks. By raising the temperature of the water, bacteria, viruses, and certain impurities can be eliminated, as most organisms cannot survive in water above 212°F.

Even though dead microorganisms and numerous impurities can settle at the bottom of the water, boiling still doesn't remove all but the imprinted substances. All contaminants are eliminated by filtering the water through a microporous sieve." The water should be covered and allowed to cool completely before being consumed after boiling. In case of non-boiled water, one or more methods must be used to make the water potable.

Filtration:

Although it's quite expensive, filtration is one of the most widely utilized and cost-effective techniques for water purification. While filtration can remove some or all of the minerals, it is also considered the best method for producing purified water that is healthier. In order to ensure water is safe for human use, various chemical and physical techniques are used to remove harmful substances. The removal of dangerous substances, including small particles that can accumulate within water and cause waterborne illnesses, is made easy by filtering water.

Today, the most dependable method in homes is through electric reverse osmosis (RO) purifiers that include UV and UF filters. There are several other methods to purify water, which we will discuss below.

1.Rapid sand filter.

2.Slow sand filter.

3.Bank filters.

4.Membrane filtration.

Disinfection:

The current focus should be on eliminating any remaining parasites, bacteria, and viruses.' Water can be treated with one or more chemical disinfectants, such as chlorine or chlorine dioxide, for this purpose. What is the reason behind water treatment plants adopting this technique? Chemical disinfectants are employed to prevent the safe transmission of water to homes and businesses by removing any impurities before it can be used for other purposes. Water purification is achieved through the use of disinfectants, while infection neccesitates the elimination of harmful microorganisms. Water and viruses and bacteria are eliminated by filters while it's being filtered. This process disinfects the water. Chlorine is added to these filters to make the water purified.

1. Chlorine Disinfection.

2. Chlorine Dioxide Disinfection.

3. Chloramine Disinfection.

4. Ozone disinfection

5. UV disinfection[8].

Coagulation:

The first part of cleaning water is coagulation. This involves putting positively charged stuff into the water. This cancels out the negative charges on the dirt and other things mixed in. Iron and certain salts can do this.

Flocculation:

To create larger, heavier clumps known as flocs, the water is then carefully mixed. More stuff is usually added to help these clumps form without trouble.

Sedimentation:

When the flocs arrive, their weight causes them to sink to the bottom. This is sedimentation. Water plants use this to get the solids, like flocs, out of the water before moving to the next phase[9].

Distillation:

Distillation cleans water with heat. It catches the water that condenses from steam. This makes sure the water doesn't have gross things, heavy metals, or bad stuff. But, distillation isn't as good as filtration. It takes a while, needs heat, and can be expensive. It also gets rid of the good minerals in the water. With distillation, water is heated to boiling and turned to steam. The steam is gathered in a condenser to cool it. When it cools, the steam becomes liquid water that's ok to drink. Big enterprises utilise different methods to clean their water because this works best for little amounts.

Other water purification techniques

Oxidation:

Chemical oxidation gets rid of inorganic stuff like iron and manganese. It also helps to remove clumps of particles and gets rid of bad smells and tastes. Oxidation is often used before other treatments like coagulation and sedimentation so that they work better to remove small particles, inorganics, tastes, and odours. Oxidants are added as a liquid or a gas.

Adsorption:

With adsorption, water is cleaned of both organic and inorganic bad stuff. Adsorption works by building up a solid, called adsorbents, on a surface. These adsorbents include things like metal oxide, ion exchange materials, and activated carbon. Flocculation creates floc, which can trap both inorganic and organic carbon, like arsenic. Activated carbon is good at removing many different organic pollutants.

Solar Purification & UV Radiation:

Solar purification is another option other than UV filtration/disinfection. It means treating dirty water with UV rays from the sun. You just fill a container or bottle with water, shake it up to get the oxygen going, and then leave it out flat in the sun. This easy trick does a great job of killing bacteria and viruses in the water, so it's safe to drink.

When water is exposed to UV light, microorganisms can't reproduce. But remember, if you don't use a reverse osmosis (RO) filter, you won't be able to remove any impurities or heavy metals.

Adding Iodine:

You can kill germs and viruses by dissolving iodine pills or drops in water. It's a strong way to disinfect, but it makes the water taste bad. Too much iodine can even be deadly. So, only use iodine to purify water if you don't have any other choices.

How To Test Water Quality?

When water is going to be utilised for human consumption, it is very crucial to test its purity .The following factors are assessed in order to assess the quality of the water:

- Temperature
- Dissolved oxygen
- pH
- Total suspended/dissolved solids (turbidity sensor)
- Conductivity
- Nutrients
- Metals
- Hydrocarbons
- Industrial chemicals[8]

EVALUATION TESTS

1 .Physical test

- Colour
- Odour
- Taste
- Turbidity
- Total dissolved solids
- P^H
- Temperature

2 .Chemical tests

- Hardness
- Chlorine residuals
- Alkalinity
- Nutrients (nitrates, nitrites, ammonia, phosphates)
- Heavy metals
- Ammonia
- Chemical oxygen demand and biochemical oxygen demand

3.Biological tests

- Total coliform count
- Fecal coliform count
- Pathogen identification test

4.specialized test(if needed)

- Pesticide residues
- Radioactive contaminants

Volatile organic compounds

Water purification solutions using locally available natural resources

Natural substances like Moringa seeds, Tulasi (Holy Basil), and Nirmali seeds have proven antimicrobial, coagulant, or filtration properties that help remove contaminants, pathogens, and impurities from water. These eco-friendly and biodegradable materials are readily available in many areas, making them affordable and sustainable solutions for local water treatment. This method promotes traditional knowledge and biodiversity. It also helps reduce reliance on costly chemical treatments and plastic-based filtration systems.

➢ Water Purification Procedure Using Moringa Seeds

Moringa Oleifera seed (MOs), a miracle tree that can handle dry conditions and salty soil, is a go-to natural option for water cleaning. Moringa oleifera seeds can be used as a natural coagulant (primary coagulant) in household water treatment as well as in the community water treatment systems[10].

You can use Moringa Oleifera seeds to clean water at home or in a bigger community setup. It's a plant found in tropical and subtropical places and has been used as food, medicine, and to clean water. Almost all parts of the

plant are useful. The leaves, which have lots of antioxidants, are usually dried and ground up .Moringa Oleifera can treat water in different ways. It helps remove solids and other stuff from wastewater upfront. It can also get rid of dissolved gunk later on. And it can filter out anything left behind, like germs[11].

The approach to cleaning wastewater involves using its seeds as a natural way to clump things together. It works because the proteins in Moringa Oleifera grab onto the bad stuff in the water and form bigger clumps. These clumps then sink to the bottom or get filtered out.

This way of doing things is seen as better for the environment compared to using chemicals, which can be pricey, harmful, and create waste. It's good at clearing up cloudy water, getting rid of solids and other unwanted stuff, and killing germs. The seeds of M. oleifera are thought to be the best natural option. They're full of things that help clump stuff together, which cleans the water. The active stuff in Moringa, like cationic polymers, and what you get when you soak the seeds in water, hold proteins that make it a good water cleaner[12].



Fig:1 Moringa Oleifera

- **Water Purification Procedure Using Tulasi (Holy Basil)**

Tulsi is known as Ocimum Tenuiflorum, Holy basil or Ocurimum Sanctum Linn in the scientific name of the city. Leaves are dropped into drinking water Purification and for medication.

Various biologically active compounds, including ursolic acid, apigenin, and luteolin have been isolated from the leaves. The leaf's phytochemical compounds include eugenol, triterpenoid, caryphyllene, penicillin, butanolenic acid; vitamin A and C supplementation with cellulose are also present in seeds.

As a repellent against harmful insects, the Tulsi plant is also known to purify or de-pollute the air. Its roots, leaves, and seeds possess a wide range of medicinal properties, providing countless advantages to human health. The title of 'Queen of Herbs' in India is often associated with Tulsi, which is known for its anti-aging, immunomodulatory, antimicrobial, and anticancer properties [11].

The remedy is also utilized to treat ailments like fever, bronchitis, arthritis, and convulsions. Ocimum sanctum or holy basil, which is synonymous with Tulsi, has a special place in the Hindu community due to its unique meaning. The word TULSI literally means "one without more.". Tulsi, a natural remedy and herbal medicine, is revered in Ayurveda as an essential oil that has antibacterial, viral, antifungal, probiotic, antibiotic, mosquito repellent (anti-emesis), oral, throat, digestive, and sexual properties. It also holds spiritual and medicinal benefits [13,14].



Fig:2 Holy Basil

Water Purification Procedure Using Nirmali Seeds (Strychnos potatorum)

Nirmali seeds, also known as Clearing Nuts, are a natural antibacterial that has been used to treat turbid water for centuries. Ayurvedic plants, such as Strychnos potatorum, are commonly used for water purification due to their high content of polysaccharides and proteins, which act as natural flocculants by aiding in the formation of suspended particles. None the less, elevated levels of moisture and subsequent metal exposure necesitate pre-

treatment and dosage adjustments to guarantee safeness. A sustainable water purification solution that's both efficient and effective requires additional research for large-scale applications[15].

Effective in water purification. These were employed for the purpose of purifying water. Indian subcontinent existed 4000 years ago. Strychnos potatorum locally called 'Nirmali'. The stone age saw the use of 'Nirmala', which was used to produce potable substances[16].

The anionic polymer in potatorum (water) is composed of angionytic polymers. The primary active ingredients are hydroxyl (OH-) and carboxyl (COO).Other constituents include proteins, alkaloids, carbohydrates, and lipids. Strychnine was found in the seeds of Strychnos potatorum.

According to current theories, anionic polyelectrolytes may be the cause of the coagulative activity of germinating seeds (Strychnos potatorum).

Interphase is caused by inter particle decay in water. The-COOH and –OH groups in seed can boost the plant's output. Among the aromatic hydrocarbons, Galactomannan and galactan are two groups that combine to form polysaccharide groups. Removing the essential oils from seeds is another way to reduce turbidity.

Up to 80%. An alternative method for coagulating Nirmali seeds.'

An idea of how polymers behave when they are dissolved.

These are particles formed by the polymerization of Nirmali seeds into water.

Comprises of various charged functional groups within its composition.

Polymers such as -OH, -2COOH and -3NH.

The coagulation Process involves four main mechanisms

A) Bridging Mechanism.

B) Charge Neutralization.

C) Double Layer Compression.

Nirmali seeds are coagulated and extracted using a Sweep-Floc mechanism. This is because the seeds are made of anionic polyelectrolytes.

The microbe extract Carbohydrate, lipids, and alkaloids are part of Nirmali's diet. The body contains a vast quantity of these substances.

Coagulating is facilitated by the presence of both -COOH and –OH groups.

Diabetes, lung conditions, and bacterial infections can all be treated using Strychnos potatorum seed, which purifies water.

In some places, Strychnos potatorum's ripe fruit pulp is used to make soap and laundry detergent[17].



Fig:3 Strychnos potatorum

CONCLUSION:

In conclusion, the use of natural materials such as Moringa seeds, Nirmali seeds, Tulasi, and Neem presents a sustainable and eco-friendly approach to water purification. These plant-based agents are rich in bioactive compounds with antibacterial, antifungal, and coagulant properties that effectively reduce turbidity, eliminate harmful microorganisms, and improve the overall quality of water. Unlike chemical treatments, they are safe, biodegradable, and affordable, making them particularly valuable for rural and resource-limited communities where access to clean water is a challenge. Moringa and Nirmali seeds act as excellent natural coagulants, helping in sedimentation of impurities, while Tulasi and Neem contribute strong antimicrobial action, ensuring that the purified water is safe for consumption. Together, they provide a holistic method of water treatment that balances efficiency, cost-effectiveness, and environmental sustainability. Promoting the use of these natural purifiers not only addresses public health concerns but also reduces dependence on synthetic chemicals. Thus, traditional knowledge combined with modern validation highlights the potential of these plants as promising solutions for ensuring access to clean and safe drinking water in an environmentally responsible manner.

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