Problems of ground water contamination with focus on water borne diseases, causes and prevention

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ABSTRACT

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Safe water supplies and environmental sanitation are vital for protecting the environment, improving health and alleviating poverty. Improving access to safe drinking-water can result in tangible benefits to health. Water is potable if it is free of disease-producing microbes and harmful chemical substances. According to World Health Organization, the drinking water quality is usually related to acceptable variables i.e. physical, chemical and biological. If any of the contaminant is found to be present in drinking water, it may cause water borne diseases. These are the most prevalent infectious diseases in the developing countries. Water borne diseases are most common cause of death in India nearly 80 %. In this paper a special focus has been placed on water borne diseases, their causes, and prevention.

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Introduction

In India, there is great diversity in every aspect. It is also true in case of water availability and scarcity. Country can be divided into two region i.e. water plenty region and water scarcity region. Uttar Pradesh, Bihar, Kerala and West Bengal are some of the water plenty states in India, whereas, Rajasthan and Gujarat are among the water scarce area. People from water plenty areas has a habit of consuming plenty of water, even when they come to water scarcity regions. They do not realize value of water thus consume more, since pain of carrying water is not realized by them (Ghosh, 2002). However, at some places like Rajasthan, water is the main concerning issue - the daily job for women consists of sourcing water for their household. Hence these people do realize the value of water and consume water more carefully.

Places with adequate water supply struggle to sustainably manage the use of it while others struggle with the reality of scarce clean drinking water. Underlying this imbalance in water availability is the main cause of water-borne diseases.

Water-borne diseases and water-caused health problems are mostly due to inadequate and incompetent management of water resources and are major causes of morbidity and mortality worldwide. Sometimes the water gets contaminated at source due to various reasons and mainly due to inflow of sewage into the source. Human health can be affected by drinking the polluted water either directly or by use of such water in food or use for the purposes of personal hygiene and recreation. The problem is especially acute where general hygiene and environmental sanitation are poor and where there is inadequate supply of safe water. Open drainage in towns and cities can have severe consequences such as water-borne diseases, like cholera, malaria and diarrhea as a result of improper management of the water supply as well as discharge. This matter is of serious concern as these diseases are a common cause of death.

As per published news, according to World Resource Report about 70 per cent of India’s water supply is seriously polluted with sewage effluents. United Nations also reported that India’s water quality is poor and over one lakh people die of water-borne diseases annually. India ranks 120th among the 122 nations in terms of quality of water available to its citizens.

Our health is affected by drinking polluted water either directly or by use of such water in cooking or for other personal purposes. The microorganisms of these diseases multiply in the body of the infected person. The infection is excreted with stool or urine. Therefore, improper disposal of human excreta is the chief cause of contamination of water of rivers, wells, lakes and shallow hand pumps and results in the spreading of these diseases. The extent of contamination in some Indian rivers...
estimated by fecal coliform. Many diseases like trachoma, scabies, skin sepsis and fungal infection are not water-borne but their incidence depends more on the quantity of water available for use. Among the water related diseases diarrhea, jaundice, guinea worm, Japanese encephalitis, malaria, filariasis, knock-knees are prevalent in our country.

Causes

Water-borne diseases are infectious diseases spread primarily through contaminated water. However, apart from that, water borne diseases can be spread through other means such as via clothes, hands, foods, materials used for cooking, eating, and drinking. Pathological microorganisms can enter the body through an open wound, eyes, and nose as well. Typhoid fever, dysentery, diarrhea, cholera, hepatitis, worms, and polio are some of the widespread water borne diseases. Though these diseases are spread either directly or through flies or filth, water is the chief medium for spread of these diseases and hence they are termed as water-borne diseases.

According to Bradley’s classification (1977), water related disease can be defined as “Water related disease is one which in some way is related to water or to impurities within water”. These can be divided into two group:

A. Biological/Specific (water borne-Diseases)
B. Non-Infectious/Non Specific water related Diseases

A. Biological/Specific (water borne-Diseases):

These diseases are mainly caused by Protozoa, viruses or bacteria. These are further classified into

a) Caused by the presence of an Infective agent
b) Due to the presence of an Aquatic host

B. Non-specific/Non-infectious Water Related Diseases

These diseases are due to either excess or deficiency of certain chemicals in the water(Chemical Hazards)

1. Lead Poisoning
2. Endemic Goiter
3. Dental Caries/Dental Decay
4. Fluorosis
5. Infantile Methaemoglobinemia

Water Borne Diseases

Exposure to polluted water can cause diarrhoea, skin irritation, respiratory problems, and other diseases, depending on the pollutant that is in the water body. Stagnant water and other untreated water provide a habitat for the mosquito and a host of other parasites and insects that cause a large number of diseases especially in the tropical regions.

Water-borne diseases like cholera, gastroenteritis, diarrhoea erupt every year during summer and rainy seasons in India due to poor quality drinking water supply and sanitation. Most dangerous water related diseases that occur in India are described as follows:

Malaria

Malarial fever is spread by the Plasmodium parasite mosquito that breeds in water bodies like lakes, paddy fish and stagnant water. Malaria can kill a child who does not have the immunity against malaria.

Typhoid

Fluctuating high fever, exhaustion, sleepiness, diarrhea etc are the signs of typhoid. The infection spreads through contaminated food and water or through close contact with an infected person. Typhoid vaccine is available for protection against the disease.

Filariasis

Filariasis is a parasitic disease and affects people who live near unsanitary water bodies or sewages. It can lead to loss of sight, and rapid skin pigmentation and the filarial worms can affect various parts of the body. It is a concern for the rural population in India whose major occupation is agriculture.

Hepatitis A and E

Hepatitis means inflammation of the liver. Different viruses such as hepatitis A, B, C, D and E cause the disease. Both Hepatitis virus A and E are water-borne diseases. Consumption of water or food contaminated by the HAV or HEV infected person causes hepatitis. Vaccine is available for hepatitis A. However, there is no vaccine for hepatitis E infection.
Polio

Polio is a communicable disease which is categorized as a disease of civilization. Polio spreads through human-to-human contact, usually entering the body through the mouth due to fecally contaminated water or food (fecal-oral transmission). Polio is a horrid disease because it tends to infect children under five, causing lifelong crippling conditions. There is no cure for polio, but there are two vaccines, meaning the strategy to eradicate the disease is focused on prevention.

Rotavirus Diarrhea

Rotavirus is the most common cause of severe diarrhea among infants and children throughout the world. Most unvaccinated children become infected with rotavirus by age of three. Rotavirus causes fever, vomiting, and watery diarrhea. Rotavirus infection is highly contagious.

E. coli Diarrhea

Diarrheal infection is spread through food and drinking water that has been contaminated. A diarrheal attack can last up to 2 weeks and leave the person completely dehydrated.

Dysentery

Ingestion of water contaminated with four different species of Shigella bacteria can cause dysentery. The symptoms include stomach pain followed by watering diarrhea. Treatment is similar to that of diarrhea.

Cholera

Cholera is a water related disease, caused by Vibrio cholera bacteria and is diarrheal in nature. It can kill in hours if left unattended. Cholera strikes when one ingests water that is infested with the bacterium. Epidemics of cholera are common during floods and monsoon season. People living in poverty, residing in crowded areas without adequate sanitation are more susceptible to cholera. Cholera vaccine offers protection.

Amebiasis

Amebiasis or amebic dysentery is caused by the protozoan Entamoeba histolytica. Amebiasis is an intestinal infection in which cysts are passed in the feces. Amebiasis is the third leading parasitic cause of death worldwide, surpassed only by malaria and schistosomiasis. On a global basis, amebiasis affects approximately 50 million persons each year, resulting in nearly 100,000 deaths.

Improved sanitation and clean water supply decrease the incidence of amebiasis. Drinking water can be rendered safe by boiling or iodination with tetracycline hydroperiodide. Nevertheless, drinking water is usually not much of the problem.

Giardiasis

It is a diarrheal infection of the duodenum and small intestine caused by a single-celled organism called Giardia lamblia (a flagellated protozoan parasite). Infection ranges from asymptomatic colonization to acute or chronic diarrhea and malabsorption. It is more prevalent in children. It can be prevented by proper hand washing, purify public water supplies adequately include chlorination and filtration and by brisk boiling of water for at least 1 min.

Cryptosporidiosis

It also known as crypto, a parasitic disease caused by Cryptosporidium, a coccidian protozoan parasite (Sporozoa). Crypto affects the intestines and is typically an acute short-term infection. Cryptosporidium can infect several different hosts; can survive most environments for long periods. It is spread through the fecal-oral route, often through contaminated water in swimming pools.

Weil’s Disease

Weil’s disease is a severe form of a bacterial infection known as leptospirosis. Leptospirosis is caused by bacteria from the genus Leptospira. The infection typically only causes mild flu-like symptoms, including headaches and chills. In severe cases, such as in Weil’s disease, it can lead to organ failure and bleeding. Leptospirosis is spread to humans by contact with soil or water contaminated with the urine of certain wild animals, including cattle, pigs, dogs, and rats. Symptoms include fever, chills, muscle aches, headaches, nausea and vomiting, cough, loss of appetite. Severe infections, which are referred to as Weil’s disease, only occur in about 10 percent of cases. People who work with animals can help prevent infection by wearing protective gear, like water-proof shoes, goggles, and gloves. Proper sanitation and rat-control measures are also helpful to prevent spread of the bacteria.
Schistosomiasis

Schistosomiasis is a chronic, debilitating parasitic disease infecting more than 200 million people and is second only to malaria in terms of public health importance. Of the estimated 200 million infected people, more than half have symptoms and 20 million exhibit severe disease manifestations. It continues to threaten millions of people particularly the rural poor in the developing countries. There are five species of schistosomes that can infect humans, of which S.mansoni, S.japonicum and S. haematobium are the most important ones.

Ascariasis

Ascariasis is an intestinal infection caused by a parasitic roundworm. Globally it is the most common human infection caused by worms. It occurs most often in areas with poor sanitation or crowded living conditions. Children are more likely than adults to develop gastrointestinal symptoms with an ascariasis infection. Ascariasis is common in warmer or tropical climates, particularly in developing nations, where it can affect large segments of the population. Ascariasis is rare in the United States, due to strict sanitation rules and regulations. The most important measure of protection against ascariasis is the safe and sanitary disposal of human waste, which can transmit eggs.

Threadworm Disease

Threadworm infection, which is also called strongyloidiasis, occurs in most countries of the world but is natural to (endemic in) tropical and subtropical climates. Human beings are universally susceptible to threadworm infection, although adults and older children are at greater risk of infection than younger children. Threadworm infection is caused by Strongyloides stercoralis, a roundworm that lives in soil and can survive there for several generations. Threadworm infections are treated with medications. Patients with severe infections should be given protein replacement, blood transfusions, and fluids to replace losses from nausea, vomiting, and diarrhea.

Hydatid Disease

Hydatid disease is also referred to as echinococcosis or echinococcal disease. It results from an infection due to a tapeworm of genus Echinococcus. Human echinococcosis is a zoonotic infection (i.e it is a disease of animal kingdom that sometimes can be transmitted to humans). This microscopic tapeworm is found in foxes, dogs and cats. Human cases are rare.

Dracunculiasis

Dracunculiasis, also called guinea worm disease (GWD), is a nodular dermatosis produced by the development of Dracunculus parasite in the subcutaneous tissue of mammals. The primary mode of prevention is through behavior change, alongside the provision of clean water sources and the treatment of contaminated drinking water with larvicides.

Diphyllobothrium

Diphyllobothrium is a genus of tapeworm which can cause Diphyllobothriasis in humans through consumption of raw or undercooked fish. The principal species causing diphyllobothriasis is Diphyllobothrium latum, known as the broad or fish tapeworm, or broad fish tapeworm. Symptoms of diphyllobothriasis are generally mild, and can include diarrhea, abdominal pain, vomiting, weight loss, fatigue, constipation and discomfort. Diagnosis is usually made by identifying proglottid segments, or characteristic eggs in the feces.

Chemicals In Drinking Water

Chemicals in water can be both naturally occurring or introduced by human interference and can have serious health effects. Various elements and their effects on health are described here:

Fluoride. Fluoride in the water is essential for protection against dental caries and weakening of the bones, but higher levels can have an adverse effect on health. In India, high fluoride content is found naturally in the waters in Rajasthan. Maximum permissible limit of fluoride in drinking water is 1.5 mg/l as prescribed by BIS (2012).

Arsenic. Arsenic occurs naturally or is possibly aggravated by phosphorus from fertilizers. Its high concentrations in water can have liver and nervous system damage, vascular diseases, skin diseases, vomiting, diarrhea, numbness in hands and feet, partial paralysis, blindness and also cancers of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate in human being. Arsenic occurs in higher concentrations in drinking water in West Bengal. BIS (2012) have set the arsenic standard for drinking water at 0.05 mg/l (permissible in the absence of alternate source).

Lead. Pipes, fittings, solder, and the service connections of some household plumbing systems contain lead that contaminates the drinking water source. It causes decreased bone and muscle growth, kidney and nervous system damage, high
blood pressure and other digestive problems when found in higher amount. Although it is very useful metal for human being but there is no safe level of lead and not permissible level in absence of alternate source (BIS, 2012).

Manganese. Low levels of manganese in the diet are considered to be nutritionally essential in humans. On the other hand, chronic inhalation exposure of humans to manganese results primarily in effects on the nervous system. Slower visual reaction time, poorer hand steadiness, and impaired eye-hand coordination were reported in several studies of workers occupationally exposed to manganese dust in air. Other chronic effects reported in humans from inhalation exposure to manganese are respiratory effects such as an increased incidence of cough, bronchitis, dyspnea during exercise, and an increased susceptibility to infectious lung disease. Metallic manganese is used primarily in steel production to improve hardiness, stiffness, and strength. Total concentration of Manganese (as Mn) shall not exceed 0.3 mg/l in drinking water (BIS, 2012).

Iron. Iron is an essential part of hemoglobin; the red colouring agent of the blood that transports oxygen through our bodies. Iron may cause conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues. Chronic inhalation of excessive concentrations of iron oxide fumes or dusts may result in development of a benign pneumoconiosis, called siderosis. Total concentration of Iron (as Fe) shall not exceed 0.3 mg/l in drinking water (BIS, 2012).

Other Heavy metals. These contaminants come from industrial activity, mining waste and tailings, landfills, or hazardous waste dumps.

Petrochemicals. Petrochemicals contaminate the groundwater from underground petroleum storage tanks. They can be absorbed through the skin or might be ingested, they can accumulate in human tissues and organs such as the brain and liver and can cause brain, nerve and liver damage, birth defects, cancer, asthma, hormonal disorders, and allergies. Chlorinated solvents. Chlorinated solvents are used for a wide variety of commercial and industrial purposes, including degreasers, cleaning solutions, paint thinners, pesticides, resins, resins, and/or metal. A host of other mixing and thinning solutions. Workers can be exposed to chlorinated solvents through the absorption of solvents, through inhalation and skin contact. Short-term side effects may include dizziness, fatigue, headaches, and/or skin rashes. Long-term side effects may include chronic skin problems, and/or damage to the nervous system, kidneys, or liver. Some chlorinated solvents are also known to cause cancer, in both humans and animals.

Salts. It makes the fresh water unusable for drinking and irrigation purposes.

Nitrates. Drinking water that gets contaminated with nitrates can prove fatal especially to infants that drink formula milk as it restricts the amount of oxygen that reaches the brain causing the ‘blue baby’ syndrome or methemoglobinemia. It is also linked to digestive tract cancers. It causes algae to bloom resulting in eutrophication in surface water. Acceptable limit of nitrate in drinking water is 45 mg/l as prescribed by BIS (2012).

Pesticides. Studies have found that people who work with organophosphates and the carbonates present in pesticides have a higher risk for many different types of cancers, including leukemia, kidney, brain, testicular, prostate and cervical cancers, and Non-Hodgkin's Lymphoma (NHL). Some of the pesticides contain carcinogens that exceed recommended levels. They contain chlorides that cause reproductive and endocrinal damage.

**Preventive Measures**

News published in daily news paper tells that as result of a survey conducted in Kolkata, it was observed that waterborne diseases like cholera, jaundice, typhoid, diarrhea as well as common cold, cough and fever accounted for 79% ailments with malaria, dengue and other diseases making up the rest (The Times of India, 2013). These are the main cause of childhood death, especially with diarrhea. They are caused by various bacteria, viruses, and pathogenic microorganisms inhabiting poorly treated drinking water and wastewater or occurs after a natural disaster, like flooding. They are contagious in nature hence their prevention requires high standards of hygiene and sanitation. Due to spreading nature they are extremely harmful and lead to severe illness and sometimes may even be fatal. Therefore, prevention of waterborne diseases is vital. Keeping this in mind proper management of water resources has become the need of the hour as this would ultimately lead to a cleaner and healthier environment.

In order to prevent infectious water borne diseases, it is important to take necessary precautions. Some points to be remember every time to check water pollution and water borne diseases:

- **Disinfect the water**, before use for purposes like drinking, cooking, if water is contaminated.
- **The quality of water should be improved at the source itself.**
- **The city water supply should be properly checked and necessary steps taken to disinfect it.**
- **Water pipes should be regularly checked for leaks and cracks.**

At home, the water should be boiled, filtered, or other methods and necessary steps taken to ensure that it is free from infection.

Common household items such as chlorine bleach, tincture of iodine, and iodine tablets can be used to disinfect water. Another important measure that should be taken to avoid the spreading of pathological microorganisms are:

Wash hands properly before eating.
Keep your fingernails short and clean.
Use of proper toilets for defecation.
Wash food before cooking and cook food at high temperature so as to kill harmful bacteria.
Avoid flies by disposing animal and organic wastes properly.
Avoid consuming foods, fruit juices, and milkshakes from roadside vendors.
Always keep foods and beverages closed.

Avoid drinking water at parks and other such recreational places. It is best to buy bottled water or carry your own water.
Another common place where one can put oneself at risk of contracting water borne illnesses is hospitals as they can be breeding grounds of pathogenic microorganism. Always sanitize your hands and bath after visiting a hospital.

Rivers and creeks can be breeding grounds for bacteria; avoid swimming in such waters.

Washing hands is the most important method of prevention of waterborne diseases. One should wash hands before preparing food and before eating. Likewise, it is necessary to wash hands after using the toilet, changing diapers, after using handkerchief, after changing clothes or beddings soiled with feces, after caring people with water borne illness, and after playing with pets and animals.

To prevent the spreading of waterborne illnesses, people suffering from waterborne illness should be confined to themselves from work until symptoms have subsided.

**Purification Of Water**

**Natural Methods**

**Evaporation & Condensation**

Evaporation is defined as the process through which a liquid becomes a vapor. Condensation is the process through which a vapor becomes a liquid, and is the opposite of evaporation. In the case of water, the main mechanisms for evaporation and condensation are heating and cooling, respectively. In this process, what comes out is pure, clean water, as the contaminants are left behind in the unevaporated water.

**Sedimentation**

Sedimentation is the oldest known method of water purification. It is aided by the addition of chemical coagulants to produce flocs which are allowed to settle in specially designed tanks. It is a suitable process for the removal of flocs formed from silt and clay particles that are relatively heavy and settle readily. However, certain flocs are relatively light and do not settle readily and a process such as flotation must be used for their removal. Light flocs are formed when algae or organic matter is flocculated. The flocs collect as sludge at the bottom of the sedimentation tank from where it must be removed on a regular basis. The clean water leaves the sedimentation tank through collection troughs located at top of the tank.

**Oxidation**

Advanced oxidation processes (AOPs), in a broad sense, refers to a set of chemical treatment procedures designed to remove organic (and sometimes inorganic) materials in water and waste water by oxidation through reactions with hydroxyl radicals (·OH). In this process ozone (O₃), hydrogen peroxide (H₂O₂) and/or UV light are used as an oxidizing agent. AOP when applied on a right place, give a good opportunity to reduce the contaminant concentration from several hundreds ppm to less than 5 ppb.

**Percolation & Filtration through soil**

Portion of water that enters the soil can move either vertically or laterally through the soil. Significant lateral movement of water through soil is called through flow or interflow. Downward movement of water through the soil is called percolation.

Percolating water eventually makes its way to a saturated zone, where all spaces between rock and soil are filled with water. The top of the saturated zone is the water table. The water filling the spaces between soil particles and rock in the saturated zone is called groundwater. This water is used for drinking purposes.

**Artificial methods**

**Physical methods**

**Distillation**

Distillation is one of the oldest methods of water treatment and is still in use today. It can effectively remove many contaminants from drinking water, including bacteria, inorganic and many organic compounds. It is a process that relies on evaporation to purify water. Contaminated water is heated to form steam. Inorganic compounds and large non-volatile organic molecules do not evaporate with the water and are left behind. The steam then cools and condenses to form purified water.
Filtration

Water filtration acts like a sieve to remove unwanted particles from the water. The two most common water filtration systems are sediment filters and activated carbon filters. The two are often combined. Sediment filters generally remove contaminants according to size. They remove many microscopic contaminants, but some, such as viruses, dissolved pharmaceuticals, and some unwanted minerals are too small to be trapped, and these pass through instead. Most filtration systems use activated carbon to filter out contaminants, which is very effective. Carbon filters trap any carbon-based particles that pass through them.

Desalination

Desalination/distillation is one of mankind's earliest forms of water treatment, and it is still a popular treatment solution throughout the world today. In ancient times, many civilizations used this process on their ships to convert sea water into drinking water. Today, desalination plants are used to convert sea water to drinking water on ships and in many arid regions of the world, and to treat water in other areas that is fouled by natural and unnatural contaminants. Distillation is perhaps the one water treatment technology that most completely reduces the widest range of drinking water contaminants. In nature, this basic process is responsible for the water (hydrologic) cycle. The sun supplies energy that causes water to evaporate from surface sources such as lakes, oceans, and streams. The water vapor eventually comes in contact with cooler air, where it re-condenses to form dew or rain. This process can be imitated artificially and more rapidly than in nature, using alternative sources of heating and cooling.

Boiling

Vigorously boiling water for one minute will kill any illness-causing microorganisms (at altitudes above one mile, boil for three minutes). The flat taste of boiled water can be improved by pouring it back and forth from one container to another (called aeration), allowing it to stand for a few hours, or adding a small pinch of salt for each quart of water boiled.

Chemical Methods

Precipitation

Chemical precipitation is a method of water treatment. Water treatment chemicals are added to form particles which settle and remove contaminants. The treated water is then decanted and appropriately disposed of or reused. The resultant sludge can be dewatered to reduce volume and must be appropriately disposed of. Chemical precipitation can be used to remove metals, fats, oils and greases (FOG), suspended solids and some organics. It can also to be used to remove phosphorus, fluoride, ferrocyanide and other inorganics.

Removal of Hardness /Softening

Softening is the removal of hardness from water. Hard water is problematic for a variety of reasons. It may cause taste problems in drinking water and may shorten the life of fabrics washed in hard water. Finally, hard water harms many industrial processes, so industries often require much softer water than is usually required by the general public.

Disinfectants

To disinfect different water types there are a range of different processes and technologies available. Which method is the correct method for which application depends on application specific parameters? Strong disinfectant includes chlorine, UV light and ozone.

Adsorbents

Adsorbents are used in water treatment applications for removing metal impurities, such as arsenic, from both drinking and industrial waters. Adsorbents which are derived from carbon, alumina, zeolite, clay minerals, iron ores, industrial by products, and natural products viz. parts of the plants, herbs and algal biomass offer promising potential of removal.

Bleaching

Common household bleach contains a chlorine compound that disinfects water.

Biological Methods

Biological water purification is performed to lower the organic load of dissolved organic compounds. Microrganisms, mainly bacteria, do the decomposition of these compounds. There are two main categories of biological treatment: aerobic treatment and anaerobic treatment. The Biological Oxygen Demand (BOD) defines the organic load. In aerobic systems the water is aerated with compressed air (in some cases merely oxygen), whereas anaerobic systems run under oxygen free conditions.
Conclusion

Due to the unavailability of safe potable water, individuals are forced to extract groundwater at very unsafe location and depth. Poor quality water sources combined with ineffective water treatment, results in the consumption of unsafe drinking water by many residents. Presence of pathogenic viruses, bacteria and protozoan parasites in rural water is a consequence of the proximity to contamination sources whether on-farm or in a small rural community. People with under-developed or weakened immune systems are especially vulnerable to pathogen exposure with infants having risk factors that can be orders of magnitude greater than healthy adults.

There is an urgent need to identify the presence of viruses, bacteria and protozoan parasites in rural water sources. It is also required to develop water treatment technologies that can form effective barriers for these microbes. There is a need of regular enforcement of environmental sanitation laws. The local, state and the government agencies should coordinate and collaborate in the areas of sanitation and water supply so as to avert any outbreak of water borne diseases originating from communities.

Finally, the government should put up a national action plan to check the possible spread of water borne diseases and sponsor research in the rural areas on water borne diseases as a means of disaster risk reduction.

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