Assessment Of Water Resources And Status Of Quality Of Water In India

Neha Parveen, Md Safikul Islam, Md Nawaj Sarif, Lubna Siddiqui, Abdul Qadir

Research Scholar, Department of Geography, Jamia Millia Islamia, New Delhi, INDIA,
nehaanis@rediffmaill.com

Assistant Professor, Department of Geography, Jamia Millia Islamia, New Delhi, INDIA,
author3@email.com

Author University, Department of Tourism, Hotel, Hospitality and Heritage Studies Jamia Millia Islamia, New Delhi, INDIA,
author3@email.com

Abstract: We need water to sustain life and thrive. Water flourishes the cities and civilizations across the world. Without safe and adequate supplies, our communities simply cannot bloom. Less than 1 % of all the water available on the earth are fresh that we can actually utilize. We use water for purposes like drinking, cleaning, transportation, industrial activities, agricultural practices and in various other tasks. A Country like India, which has a shape of the peninsula and it is surrounded by an abundance of water has 1121 BCM Average Estimated Utilizable Water. Though estimates vary, each person uses about 80-100 gallons of water per day. The Government at various levels is trying to provide safe drinking water to maximum households. Though safe drinking water is not completely safe and there are a number of households which even do not have access to safe drinking water and that is why people have to fetch water from untreated sites and this lead to water borne diseases. In India, every year million of cases registered due to water borne diseases and over thousands of deaths occurred. So, water must be accessible and carefully treated in order to make it safe for drinking and other uses. It is the responsibility of all the citizens to be aware of the importance of clean water and help to preserve it.

Keywords: Water Accessibility, BCM, Contamination, Diseases, Sustainability.

1. Introduction

Water storage is a term which is used to locate where water is stored for later utilization. These ranges of natural water stores, such as soil, water, ground water aquifers and natural wetlands to small artificial tanks, ponds and reservoirs behind major dams, etc. In India, average annual water resources potential is 1869 BCM and estimated utilizable water (EUW) is 1121 BCM, out of which surface water is 690 BCM and ground water is 431 BCM. As per the tentative assessment carried out in the CWC, live storage capacity of the completed dams in the country is 253.388 BCM and live storage capacity of dams under construction and under consideration for construction by the respective state governments are 50.959 BCM and 109.673 BCM respectively, while at the time of Independence the live storage capacity in the country was 15.6 BCM (Status of water quality in India 2011; CPCB). Water and related statistics report by water planning and project wing, central water commission, December 2013 discussed about the utilization of water resources, social and environmental aspects of water resources development activities as well as data on flood damages and flood protection works. Census of India 2011 Analytical Report on Houses, Household Amenities and Assets Madhya Pradesh Series 24 Chapter 5 Drinking water sources and availability studied about the proximity of drinking water sources to households which is categorized into three, which is; within the premises, near the premises and away from the premises. The another aspect is the major source of drinking water consumed by the households which could incorporate tap water, wells, hand pumps, other sources, etc. John Archer, in his study "The water you drink, how safe is it?" has estimated 60,000 tonnes of fifty different chemicals being intentionally added annually in the water. Indira Khurana and Romit Sen in their study "Drinking water quality in rural India: Issues and approaches", have estimated that annually around 37.7 million Indians are affected by waterborne diseases; 1.5 million children died due to diarrhea and each year 73 million working days are lost due to waterborne disease. According to them, the consequential economic burden is approximate at $600 million a year.

2. Study Area

India is a country located in South Asia. It is the second-most populous country with 1,210,193,422 residents reported in the 2011 census report and in 2017 it is estimated 1,310,069,000 and it is the most populous democracy in the world. It is the seventh-largest country by area which is bounded by the Bay of Bengal on the south east and the Indian Ocean on the south, and the Arabian Sea on the southwest. It shares land borders with Pakistan to the west; China, Nepal, and Bhutan to the northeast; and Myanmar (Burma) and Bangladesh to the east.

3. Data Sources And Methodology

The present study is entirely based on secondary sources of data that have been collected from various national and international organizations and both government and non-government, such as from Central Pollution Control Board (CPCB)Indiastat.com.Ministry of Health and Family Welfare , WaterAid NGO and others. The techniques used for making graphs and tables is prepared with the help of Microsoft excel and Microsoft word software respectively. Graduated symbols and Graduated colour are applied to create maps with the help of software named as "ArcMap 10.3.

4. Objectives

The main objectives of the present study are:-

- To assess the total water storage capacity and the number of water bodies/tanks not in use.
- To trace out the areas having safe drinking water facilities.
- To examine the impact of various hazardous chemicals on the quality of water and human health.
- To find out the possible solutions for overcoming the water contamination issue and to give a few suggestions.

5. Results And Discussion

5.1 Total Water Storage Capacity in India

In India, there are two main sources of fresh water that is rainfall and snowmelt of glaciers in the Himalayas. It is estimated that in the Himalayas some 5, 000 glaciers cover about 43,000 sq. km with a total volume of locked water estimated at 3,870 $km^{3.}$ While it is considered that about 10,000 sq. km of this is located in Indian Territory, the total water yield from snowmelt contributing to the river runoff in India may be of the order of 200 km^3/year. India has annual average precipitation (in the form of rainfall and snow) of 4000 BCM and in 2011 it is estimated 3669.35 BCM. Due to the large spatial and temporal unevenness in the rainfall, water resources distribution in the country is highly skewed in time and over space. After accounting for percolation, evaporation and other losses, less than 50 per cent (1,869 BCM) is the total surface flow, including regenerating flow from groundwater and the flow from neighboring countries. But out of the total surface flow that is estimated 1,869 BCM, only 1,112 BCM/year is considered as utilizable quantity of water which is comprised of 690 BCM from surface water and 431 BCM from groundwater (Status of water quality in India 2011; CPCB). In 2011, the topmost state which had a capacity to store most water than any other state in the country is Maharashtra (37.358 BCM) and other states like Uttaranchal, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Odisha and Karnataka had stored water ranges from 18 to 26 BCM while Jammu and Kashmir, Haryana and North eastern states of India had stored water ranges from 0 to 4 BCM (Figure-1).

5.1.1 Number of Water Bodies/Tanks Not in Use in India

Albeit, India is not poor in water resources and a country is blessed with great oceans, seas, bays, perennial rivers, etc. and it has an abundance of water bodies but there is severe ignorance of water resources and lack of techniques used. The total numbers of water bodies not in use in India are 85,807 (Status of water quality in India 2011; CPCB). Approximately 748 BCM of available water resources is considered to be unutilizable due to a variety of factors (Status of water quality in India 2011; CPCB). The Figure 2 depicts the number of water bodies' not in use and Andhra Pradesh is the foremost state which did not use its 24,014 water bodies (figure.2). Other states like Tamil Nadu, Maharashtra, Chhattisgarh, Jharkhand, West Bengal, Bihar, Karnataka, Rajasthan and Gujarat have not used water body ranges from 1000 to 15,000 while Jammu and Kashmir, Punjab, Haryana, Uttarakhand and North eastern states of India had not used their bodies' ranges from 100 to 1000.

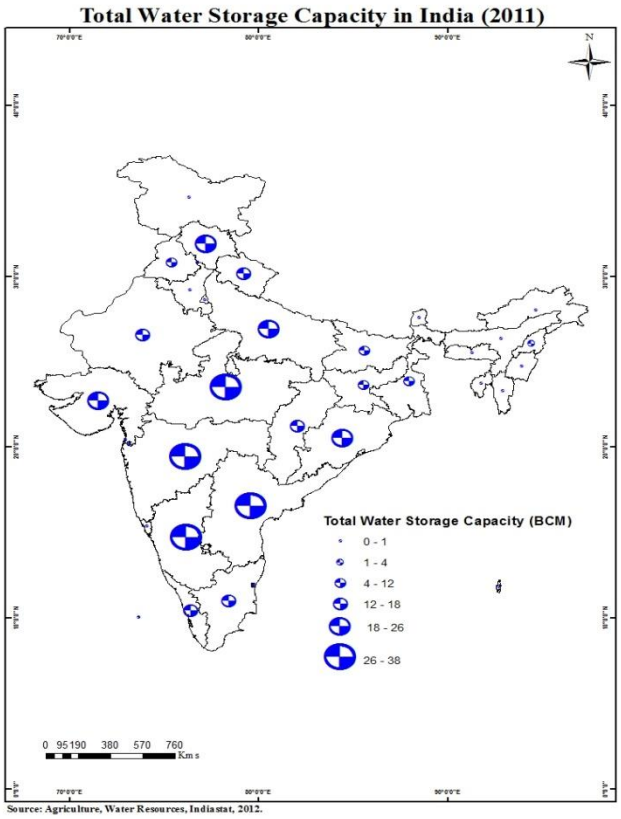


Figure 1: *Distribution of Water Storage Capacity in India*

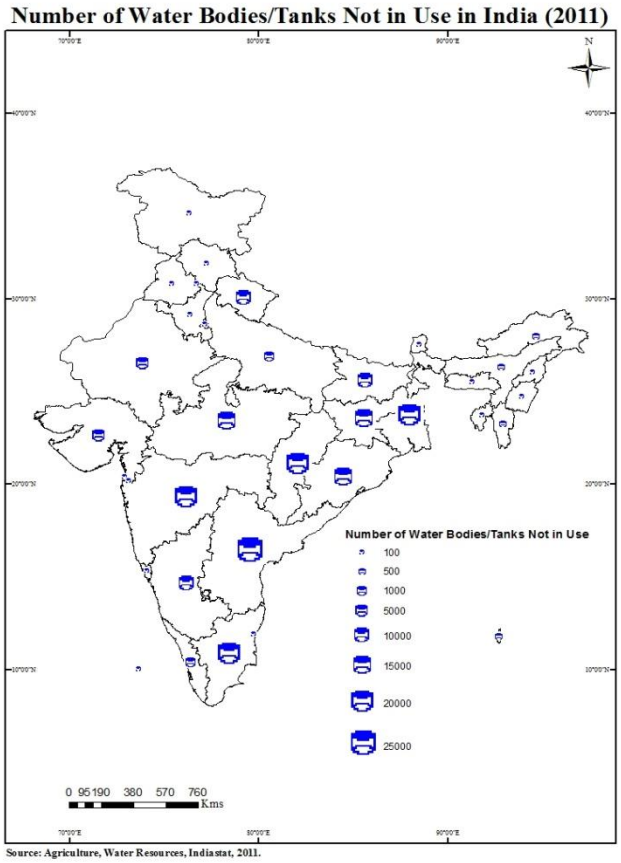


Figure 2: *Number of water bodies/tanks not in use in India*

5.1.2 Households Having Safe Drinking Water Facilities

As it is said a man can live his life without love, but not without water. Water has always been an important and life-sustaining drink to humans and is essential to the survival of

all the known organisms on earth. In India, Article 21 of the Constitution, the right to life, as encompassing the right to safe and sufficient water and sanitation, but providing drinking water to such a large population is an enormous challenge and country is also characterized by non-uniformity in level of awareness, socio-economic development, education, poverty, practices and rituals which add to the complexity of providing water. According to 2011 estimates, 85.5 per cent households are getting a safe drinking water facility, while 14.5 per cent households are left with no safe drinking water. 82.7 per cent of the rural population and 91.4 per cent of the people living in urban areas have access to safe drinking water. India is the largest user of groundwater in the world and is facing serious problems in certain states as aquifers have reached the limit to which they can sustainably be exploited (IBRD/WB Deep wells and prudence: Towards pragmatic action for addressing groundwater overexploitation in India, The World Bank, 2010). Figure 3 shows that Uttar Pradesh, Punjab, Delhi, and Chandigarh are the topmost states/UTs which are providing drinking water facilities and the least amount of water is provided by Kerala, Meghalaya and Manipur. Though urban areas are getting a good proportion of water while rural areas have to suffer from a water shortage problem at most of the places. But in some states, rural areas are receiving more safe drinking water than urban areas. Nearly 76 million people in India have no access to a safe water supply (The WorldBank(2014):http://data.worldbank.org/indicator/SI.SP R.PC40. £3 a day.). To maintain and restore the wholesomeness of national aquatic resources by prevention and control of pollution, the concept of "designated best use" (DBU) was developed which demands the highest quality of water. A summary of the use based classification system is presented in (Table 1).

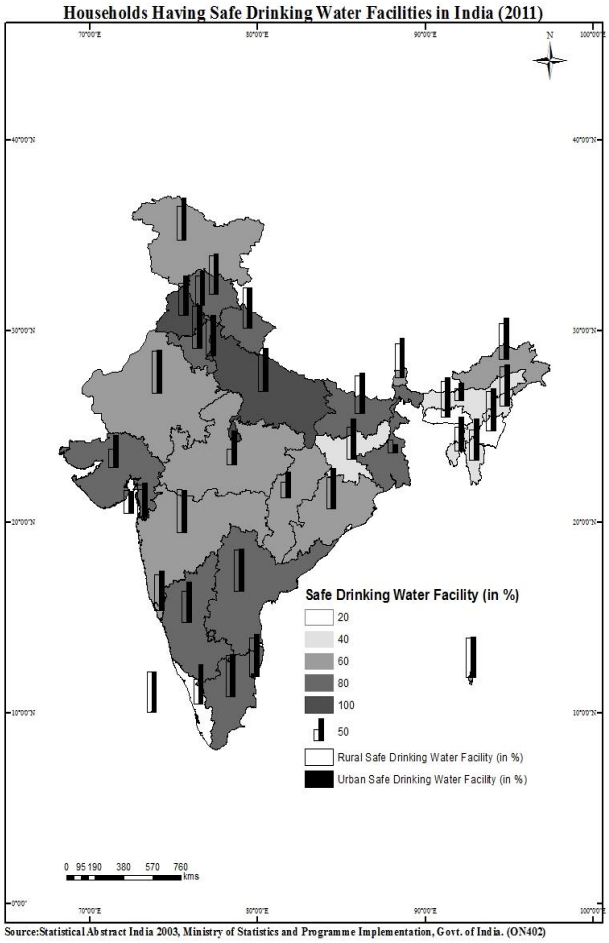


Figure 3: *Households having safe drinking water facilities in India*

Table 1: *Use based classification of surface waters in India*

DESIGNATED-BEST-USE	CRITERIA
Drinking Water Source without conventional treatment but after disinfection	Total Coliforms OrganismMPN/100ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 200C 2mg/l or less
Drinking water source after conventional treatment and disinfection	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 200C 3mg/l or less

Source: CPCB Report, Status of water quality in India, 2011

5.1.3 Number of Population Affected by Various Hazardous Chemicals and Quality of Water in India

Water circulates through the land just as it does through the human body, transporting, dissolving, and replenishing nutrients and organic matter, while transporting away waste material. Further, in the body, it regulates the activities of fluids, tissues, cells, lymph, and blood. As surface water and groundwater are not always static in their natural reservoirs, the water particles are always moving either vertically, laterally, or a combination of both through the banks and bottom of the reservoirs. Through the process of movement, the water interacts with different geologic environments that lead to the dissolution of some minerals and transportation of non-dissolvable solids. The addition of these dissolved minerals and solids changes the quality of water from one point to another. The cause of water quality variation can be classified as follows:

- Dissolution of minerals in geologic media.
- Mining activities that release heavy metals like Mercury, Zinc etc.
- Farming activities that include the use of organic and inorganic fertilizers.
- Poor sanitation around water sources.
- Industrial sources such as releases of gas fumes and other effluents from factories, tanneries etc.

- Contamination due to over-exploitation of groundwater tables etc.

Water-related diseases are a major cause of morbidity and mortality worldwide and half of India's morbidity is water related (World Health Organization, Emerging issues in water and infectious disease, 2003). In India 85 percent population depends on ground water. The speedy pace of industrialization and greater emphasis on agricultural growth combined with financial and technological problems and non-enforcement of laws have led to generation of huge quantities of waste and ultimately pollution. The report, from the Ministry of urban development 2011 and Central Pollution Control Board, estimates that 75-80 % of water pollution by volume is from domestic sewerage, while untreated sewerage flowing into water bodies including rivers have almost doubled in recent years. According to the report, titled 'Urban WASH: An Assessment of Faecal Sludge Management (FSM) Policies and Programms at the National and State Level,2014', inadequate sanitation facilities, poor septage management and a near absence of sanitation and waste water policy framework are primary reasons responsible for the groundwater and surface water pollution in the country. The hazardous levels of naturally occurring arsenic and fluoride are present in surface water and groundwater of India. Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka, and Kerala are the states where people are affected by multiple hazardous chemicals found in quality of water while in Eastern India, population are affected mainly by iron found in water quality (Figure 4). Paul C. Bragg and Patricia Bragg in their book "The shocking truth about water, 1985" argued that human brain and other body structures will become largely hardened through the use of chemical water.

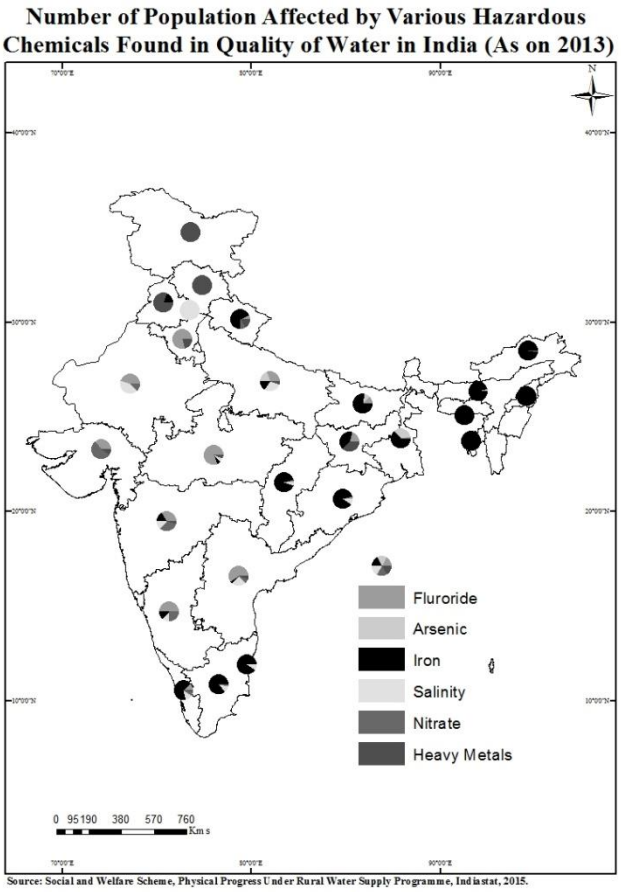


Figure 4: *Number of population affected by various hazardous chemicals found in quality of water in India*

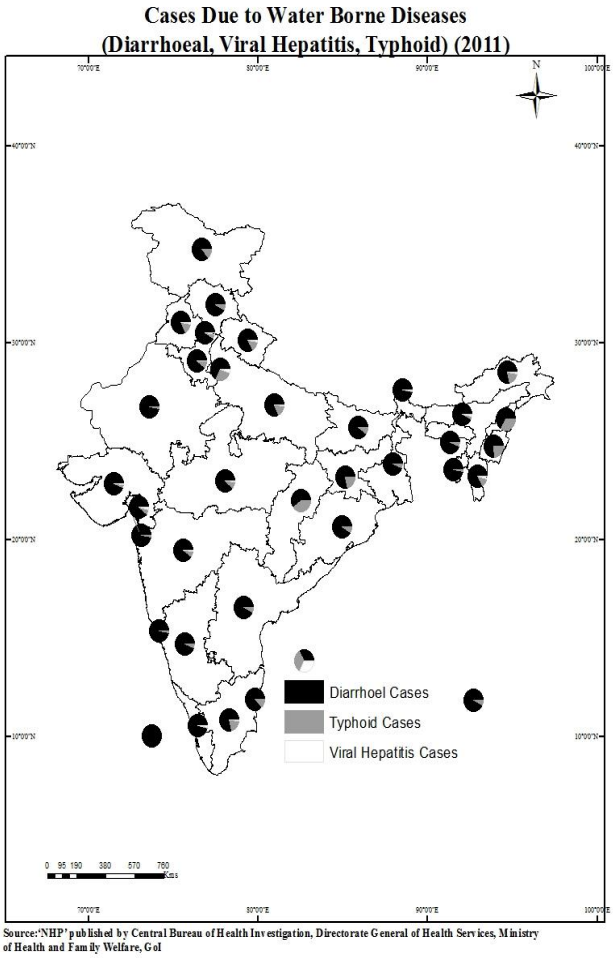
Water borne diseases can be, to a large extent, controlled by managing human consumption and production patterns. It is therefore pertinent to have an understanding of human activities, including water management initiatives, and their impacts on water and the environment. There are some parameters which should not exceed its limit in drinking water for the reason that surpassing level can affect human health (Table 2). As per Drinking Water Specifications IS:10500:1991, there are some essential and desirable characteristics which should not go beyond its permissible limit (Table 3).

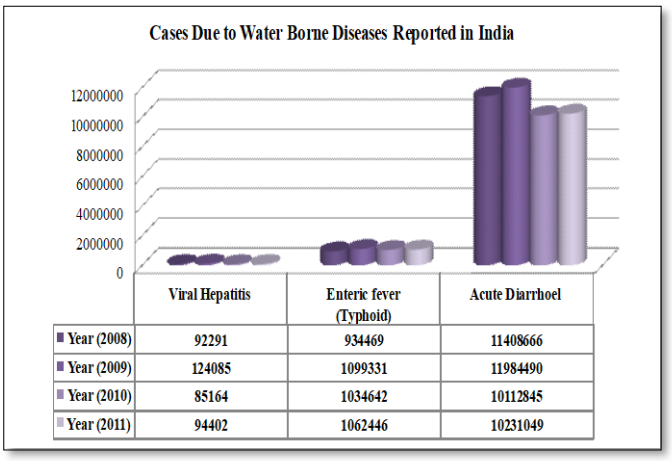
5.1.4 Cases and Deaths Due to Water Borne Diseases (Diarrhoeal, Viral Hepatitis, Typhoid)

Lack of access to safe drinking water, together with inadequate sanitation and hygiene, is the overwhelming contributor to the 1.8 million annual deaths caused by diarrheal disease. Water-borne pathogens, which are largely transmitted through a fecal-oral route, are important causative agents of disease outbreaks in the developing as well as the developed world. Most serious malfunctions in India's water-supply system is its hazardous quality and gigantic cost to human health. There are four primary routes of transmission of water-related diseases. The first route is water-borne transmission, in which water contaminated with pathogens is ingested and causes disease. A second route is water-washed transmission in which poor personal or domestic hygiene results in exposure to pathogens through a person-to-person or fecaloral mechanism. A third route is water-based transmission through skin contact with water

infested with pathogens that spend part of their life cycle in an animal that lives in water. The fourth route is water-related transmission through insect vectors that breed in water or bite near water (Water and Health – Vol. I - Transmission and Preventation of Water-Related Diseases - J.T. Macy,R.E. Quick, 2005). The major pathogenic organisms responsible for water borne diseases in India are viruses (Hepatitis A, Polio Virus, Rota Virus), bacteria (E Coli, Shigella, V cholera), and parasites (E histolytica, Giardia, Hook worm). Other contaminants include excess of iron, nitrates and brackishness, the later especially in coastal areas. In Figure 5, it is clearly shown that Diarrhoea is the predominant disease in India and more than ten million people are affected by it. West Bengal and Andhra Pradesh are the most affected states in India with diarrhoeal disease. Typhoid being the second most dominant disease in India, affected more than ten lakhs of people while viral hepatitis cases are in less than ten lakhs.

Figure 5: *Cases due to water borne diseases*





	Viral Hepatitis	Enteric fever (Typhoid)	Acute Diarrhoel
Year (2008)	92291	934469	11408666
Year (2009)	124085	1099331	11984490
Year (2010)	85164	1034642	10112845
Year (2011)	94402	1062446	10231049

Source: Health, Disease, Indiastat, 2008 to 2011.

Figure 6, shows the yearly trend from 2008 to 2011 and found that diarrhea cases declined from 2008 to 2011 while typhoid and viral hepatitis cases seen the sudden increase in the year 2009 and then it is declined in 2010 but again the diseases speeded up in the year 2011. Children who are malnourished and under nourished are more likely to suffer from diarrhoea and repeated incidences of diarrhoea result in weight loss, stunted growth and vitamin deficiency. Figure 7 manifests the deaths due to water borne diseases. Diarrhea is the disease which causes more deaths all over India. Second prominent deathly disease is viral hepatitis which is more dominant in Jammu and Kashmir, Maharashtra, Kerala, Andaman and Nicobar Island, Lakshadweep, Tripura, Odisha, Jharkhand, Uttarakhand and Assam. The deaths due to typhoid are more in Nagaland, Arunachal Pradesh, Jharkhand, Odisha, and Delhi. Diarrheal mostly affects children under the age of 5 and often leads to death. Providing safe and reliable water services can improve the health of the most vulnerable (Combating waterborne disease at the household level, The International Network to Promote Household Water Treatment and Safe Storage, WHO, 2007). The right to 'pollution free water' and the right of access to 'safe drinking water' has been read as a part of 'Right to Life' under Article 21 of the Constitution of India. Though, India might be recognized as the world's one of the fastest growing economies, but most of its people are destined to live without basic facilities like safe drinking water which results in various types of water borne diseases.

Figure 6: *Cases due to water borne diseases*

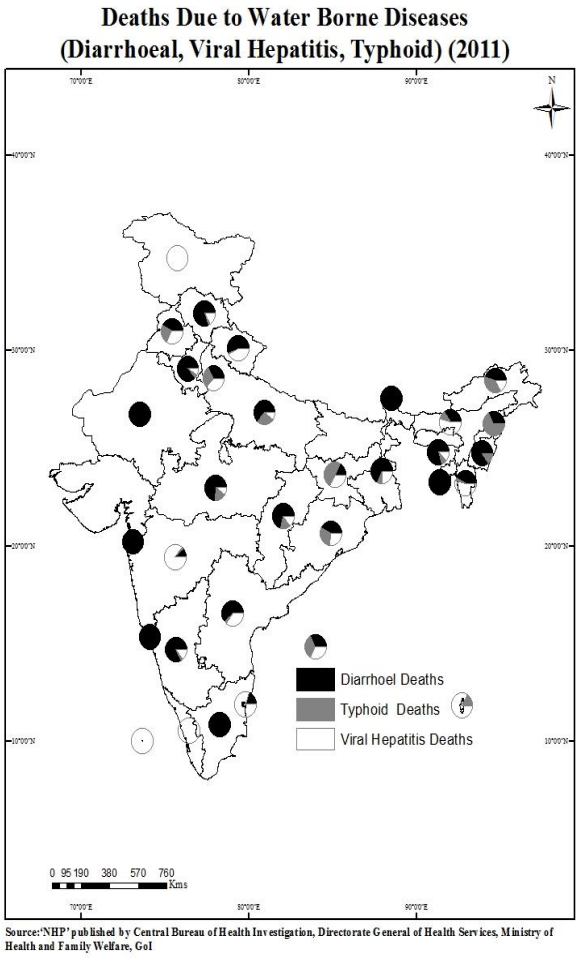


Figure 7: *Deaths due to water borne diseases*

The disappointment to supply safe drinking water and satisfactory sanitation services to all people is perhaps the greatest development defeat of the 20th century in India and the world. The most grievous consequence of this failure is the high rate of mortality among young children from preventable water-related diseases.

Conclusions and Suggestions:s

Albeit, India has good water storage capacity, but there are large number of water bodies which are not in use which entails that India has good potential of water resources which can be use in future. According to Office of Registrar General, India, Ministry of Home Affairs 2011 stated that 85.5 of Indian population are getting safe drinking water which implies that 14.5 % are without safe drinking facilities. The safe drinking water which is provided is not 100 % safe since the sources from where people fetch the water are taps from treated/untreated sources, covered/uncovered wells, tanks, hand pumps, ponds, lakes etc. where the hazardous chemicals crosses the permissible limit in water quality and inducing illness and in many cases led to death. Though, there are standards in water but the enforcement is very low. Even the amount of water, which is treated, is also not treated completely or as per standards. The chemical quality is being monitored by Central Ground Water Board once in a year while there is an urgent need to enhance the monitoring network by establishing more monitoring stations across all regions and seasonal assessments of all water sources. Data should be generated, its interpretation and communication is essential for effective management of water and the use of GIS can help in mapping, modelling and decision making. In case of contamination being detected, an action plan for dealing with sources should be provided and different treatment methods can be used (Table 4).

Table 4: *Water Treatment Methods*

PARAMETER	TREATMENT METHODS
Turbidity {measure of relative clarity of a liquid}	Cloth Filtration Slow Sand Filtration Coagulation Candle Filtration
Odour	Aeration Carbon Filtering using charcoal Boiling
Colour	Carbon Filtering using charcoal Slow Sand Filtration
Bacterial Impurities	Boiling Chlorination Ultra Violet Radiation - SODIS Slow Sand Filtration
Fluoride	Activated Alumina Technology Nalgonda Technique
Ammonia	Chlorination Boiling
Iron	Oxidation and settling
Hardness	Boiling and Settling/ Filtration Reverse Osmosis
Chloride	Reverse Osmosis
Arsenic	Ion-exchange Alum-Iron Coagulation

Source: Water Aid Drinking water quality in rural India: Issues and approaches, Water Aid 2008

To address the fresh water depletion issue, four approaches can be followed (a) Improving efficiencies and minimizing losses (b) Recharging groundwater aquifers (c) Abatement and treatment of water pollution (d) Reuse and recycling of wastewater. At individual level and users in large, the communities have to maintain hygiene near water sources. Clean water initiatives should be supported to make water sustainable for future generation. School Water Supply Programme should be conducted because children are the future of nation and they should be aware of water related problems and the impact of hazardous chemicals on human health and environment. However supplying clean water alone would not solve health-related problems. Only an integrated approach of water quality improvement with improvement in water availability combined with sanitation and hygiene education will help to address the issue.

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Author Profile

Neha Parveen, received the B.A (Geography) from Jamia Millia Islamia University,New Delhi in 2012. and M.A. degrees in Geeography from Delhi School of Economics, Delhi University in 2014, respectively. Now she is pursuing her P.hd in Geography from Jamia Millia Islamia University,New Delhi. She also qualified NET (Geography) Conducted by UGC in December 2015. She has presented many papers in International and National conferences in various universities.

Table 2: *Maximum Permissible Limits of Parameters and Health Impacts*

Parameter	Maximum permissible limit	Health impact
Fluoride	1.5 (mg/l)	•Immediate symptoms include digestive disorders, skin diseases, and dental fluorosis. •Fluoride in larger quantities (20-80 mg/day) taken over a period of 10-20 years results in crippling and skeletal fluorosis which is severe bone damage.
Arsenic	0.05 (mg/l)	•Immediate symptoms of acute poisoning typically include vomiting, oesophageal and abdominal pain, and bloody 'rice water' diarrhoea. •Long-term exposure to arsenic causes cancer of the skin, lungs, urinary bladder, and kidney. There can also be skin changes such as lesions, pigmentation changes and thickening (hyperkeratosis).
Iron	1.0 (mg/l)	•A dose of 1500 mg/l has a poisoning effect on a child as it can damage blood tissues. •Digestive disorders, skin diseases and dental problems.
Nitrate	100 (mg/l)	•Causes Methamoglobinemia (Blue Baby disease) where the skin of infants becomes blue due to decreased efficiency of haemoglobin to combine with oxygen. It may also increase risk of cancer.
Salinity	2000 (mg/l)	•Causes Methamoglobinemia (Blue Baby disease) where the skin of infants becomes blue due to decreased efficiency of haemoglobin to combine with oxygen. It may also increase risk of cancer.

Source: Water Aid Drinking water quality in rural India: Issues and approaches, Water Aid 2008

Table 3: *Drinking Water Specifications*

CHARACTERSTICS	DESIRABLE LIMIT	PERMISSIBLE LIMIT
Essential Characteristics		
Colour (Hazen units)	5	25
Odour	Unobjectionable	-
Taste	Agreeable	-
Turbidity (NTU)	5	10
PH	6.5 to 8.5	-
Total Hardness (mg/l)	300	600
Iron (mg/l)	0.3	1.0
Chlorides (mg/l)	250	1000
Residual Free Chlorine (mg/l)	0.2	-
Desirable Characteristics		
Dissolved Solids	500	2000
Calcium	75	200
Mangnesium	30	75
Copper	0.05	1.5
Mangenese	0.1	0.3
Sulphate	200	400
Nitrate	45	100
Fluoride	1.0	1.5
Phenolic Compounds	0.001	0.002
Mercury	0.001	-
Cadmium	0.01	-
Selenium	0.01	-
Arsenic	0.05	-
Cyanide	0.05	-
Lead	0.05	-
Anionic Cotorgents	0.2	1.0
Chromium as Cr6+	0.05	-
PAH	-	-
Mineral Oil	0.01	0.03
Pesticides	Absent	0.001
Alkalinity	200	600
Aluminium	0.03	0.2
Boron	1	5

Source: Water Aid Drinking water quality in rural India: Issues and approaches, Water Aid 2008