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REVIEW PAPER OPEN ACCESS

# A review of drinking water quality and its relation to human activity and public health

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## Abstract

Deterioration of quality of drinking water is one of the major threats to public health in India. Drinking water sources, across the nation are largely polluted due to the excessive presence of inorganic and organic chemicals, toxic metals and microorganisms. Both the natural and human activities contribute to this. Human activities like improper disposal of municipal and industrial wastes and improper applications of agrochemicals are the main contributing factors to the deterioration of water quality. This severe deterioration of drinking water quality has potential health impacts. A significantly large number of casualties, including children were reported every year due to the consumption of contaminated water. In this backdrop, this review focuses on the pollution of drinking water due to geogenic and anthropogenic activities as well as the consequent health problems and attempt to come up with a clear picture regarding the status of the studies and the shortcomings that needed to be bridged.

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**Introduction**

The availability of drinking water is the most important and prioritized need among the various demands because it is essential for the existence of human beings. Hence, the quality of drinking water demands top most priority. However, only 2.5% out of 71% of water on the earth's surface is fresh and appropriate for the consumption (Juneja and Chaudhary, 2013). Even within that the major quantity are locked in ice caps and glaciers and only a very few percentages, <1% of water is available for the drinking purpose (Mohsin *et al.,* 2013). Unfortunately, this limited percentage is also under the threat of pollution due to both geogenic and anthropogenic activities.

Deterioration in the quality of drinking water is a global problem, which needs to be dealt with utmost urgency as it poses severe threat to human existence. A recent survey of World Health Organization (WHO) illustrated that around 435 million people across the globe are using untreated water from various ground water sources, such as wells and springs and another 144 million are using polluted surface water, for drinking purpose (WHO, 2019). This creates a serious threat to human health as the contaminated drinking water became the root cause of several diseases, like diarrhea, cholera, typhoid, polio etc. The same report continues that over 8 lakh deaths were reported across the globe as a result of diarrhea, including around 2 lakh children aged under 5 years. This clearly reveals the magnitude of the threat. The quality of surface and ground water is regulated by various factors, including the groundwater circulation through the various rock types, climate, and geography of the region, soil characteristics, and human activities. Despite the role played by geogenic sources, the major cause of drinking water contamination is various human activities, including the improper and untreated disposal of sewage and industrial wastes, the excessive agricultural runoffs and the significantly higher use of chemical fertilizers, and the mining of radioactive elements. All these activities pollute both ground as well as surface water and make this water unsafe for drinking.

The deterioration of drinking water quality is more severe in developing countries as these countries lack the proper hygienic and sanitation facilities. India is one of the nations where the drinking water is severely polluted and suffers serious the health impacts. According to (NitiAyog, 2018) around 70% of the drinking water supply in India is polluted. Around 600 million Indians suffers extremely high freshwater crisis and almost 2,00,000 people lost their lives due to the consumption of contaminated water (The Hindu, 2018). The report also indicated that India ranks at 120$^{th}$ position among the 122 nations in terms of water quality index (NitiAyog, 2018). The main reason for the water pollution in India is various human activities, including agricultural, industrial and domestic activities. A survey by Central ground water board indicated that the availability of per capita ground water in India is reduced by 70% over 60 years (from 1951 to 2011). As per the survey per capita water availability climbed down from 5177 cubic meters in 1951 to 1545 cubic meters in 2011 (Dubbudu, 2016). This further worsens the situation and lead to the health problems as the people are forced to consume the polluted water. The present paper provides an in depth review of the studies, which explored the various sources of drinking water pollution in India and its impacts on the public health. The review focuses on the pollution due to both geogenic and anthropogenic activities and attempt to come up with a clear picture regarding the status of the studies and what are shortcomings that needed to be bridged.

Both the Groundwater as well as the surface water contains certain dissolved forms of chemicals, which can cause adverse health effects. The chronic impact of chemical contamination of groundwater is more alarming in rural areas of the developing world as the groundwater is the main drinking water source in these regions. (Thompson *et al.,* 2007) reported two major criteria for identifying the impact of chemicals on public health. They are 1) a significant hazard to health and 2) high probability of consumer exposure from drinking. A large variety of chemicals, such as Fluorides, Nitrate, Calcium, Potassium, Magnesium, etc. in their excess presence causes various health problems in humans. India is an agricultural centric nation and hence there is a high probability for the water contamination due to the Fluoride, Chloride and Nitrates. Natural water comprises impurities due to heavy metals as it dissolves these substances during its downward movement in hydrological cycle (Ilyas and Sarwar. 2003). In addition, various human activities, like improper disposal of industrial and municipal wastes and large-scale application of fertilizers in agriculture also introduce these metals to surface as well as ground water. Some of the common heavy metals presented ground and surface water include, Arsenic (As), Iron(Fe), Lead(Pb), Chromium(Cr), Antimony(Sb), and Copper(Cu). Even though several of these metals are considered as vital to human health the excessive presence of them cause water pollution and result in severe health problems in human beings. Apart from that, the traces of radioactive metals like, Uranium was also found in the ground water. The microbial pollution of drinking water is one of the severest and prominent health problems in India.

Drinking water quality degradation is a global issue that requires immediate attention since it poses a serious threat to human life and is the source of various diseases. Several factors influence the quality of groundwater, including geogenic factors like rock types, climate, topography, soil properties, and human activities. Despite the role played by geogenic sources, various human activities, such as improper and untreated sewage and industrial waste disposal, excessive agricultural runoff, and radioactive element mining, are the leading causes of drinking water contamination.

So, the present study examines the various causes and impacts of anthropogenic activities on groundwater and drinking water quality. It also involves studies on groundwater pollution caused by industrial discharges, agrochemicals, and other factors. The findings and limits of the studies on this issue were discussed. This work also focused on the various water-related disorders caused by contaminated drinking water, as well as numerous studies on public health and drinking water throughout the world. It also focuses on efforts to create a comprehensive picture of the state of research on the link between drinking water, public health, and human activities, as well as the gaps that need to be filled.

*Human activities and water pollution*

The improper disposal of industrial and sewage wastes in streams, rivers, and lakes and various agricultural activities which generate untreated and improper agricultural runoffs, causes the rise of inorganic and organic pollutants in the ground water. In addition to these, the improper handling of floods and droughts can also pollute the ground water. In recent years, the rapid rise in the population density the developmental activities increased the threat of water pollution in India and hence the topic has become a matter of great concern. One of the adverse effects of the rapid industrialization in India during the past decades is the exponential increase in the rate of inorganic pollutants in the ground water. The majority of these heavy industries, including textile, chemical, heavy engineering and mining dispose the industrial waste water to the nearby water bodies without proper treatment. This causes severe pollution in the respective water bodies, which can be used as the reservoirs of drinking water. In addition, this water percolates into the earth and pollutes the ground water also.

Mondal *et al.*, 2005 pointed out the ground water pollution caused by Tanneries in the region of upper Kodaganar river basin, Dindigul, Tamil Nadu. The authors clearly demonstrated the excessive presence of Chlorides, Potassium, Magnesium and Calcium in the ground water of the study region. The impact of Tannery industry was further pointed out by (Katiyar, 2011) who demonstrated the excessive presence of heavy metals like, Pb, Cr and As in the water of river Ganga near Jajmau area at Kanpur. The excessive presence of Pb and Hg as a result of the discharge of the pulp and paper manufacturing units situated in Diamond Harbour, the river Ganga- Babughat, and Gangasagar in West Bengal, were detected (Sarkar *et al.,* 2007). Significantly higher level of iron in the drinking water was detected in the study conducted near to the Kali River (Renu and Arun, 2009), where large number of iron industries is present. According to the researchers, the waste water discharged by the industrial unit's percolates into the earth and pollutes the ground water also the majority of developing countries face the threat of drinking water pollution due to the significantly higher composition of heavy metals and the major reason for their increased presence is the discharge of waste water from the heavy industries.

The mining industry can be another potential cause for the ground water contamination, as the mining residuals, including the radioactive wastes may percolate into the earth and pollute the ground water in those surroundings. (Kumar and Kumar, 2013) indicated the ground water contamination due to the Granite mining in the area of Jhansi. The authors pointed out the increased levels of $Ca^{+}$, $Mg^{+}$ and $NO_3$ in the ground water of the study area. The possible contamination of ground water due to the presence of Uranium was pointed out in the study conducted in Kolar district (Babu, 2008), which is famous for gold mines and granite rocks. The authors, through their findings, showcased the higher presence of Uranium in the groundwater of Northern districts of Kolar. However, the study could not clarify the sources of these Uranium concentrations and assumes it dissolved into water originated from the Granite rocks. Meanwhile, (Sarvajayakesavalu *et al.,* 2018) argued that there was no threat from the radioactive pollutants and the radioactive concentration in ground water across the state of Karnataka was well within the safe level. Adding the confusion and demanding further studies. In the study conducted at Tummalleppalle mine, India, indicated the possible presence of Uranium in the ground water, however, with the very low possibility of any health impacts (Rana *et al.,* 2016).

Besides the industrial wastes, domestic and municipal wastes also play its role in polluting the ground and surface water. The domestic wastes comprising human wastes and household effluent are discharged directly to a water body or open or agricultural land. These wastes, which largely contain the microorganisms like, *E. Coli* pollutes the surface water to which it merges. In addition, it also pollutes ground water through the percolation into the earth (Brinda and Elango, 2011). (Chautmal *et al.,* 2011) pointed out the chemical and biological contamination of ground water in Dhule, Maharashtra due to the irresponsible treatment of sewage water. (Golekar *et al.,* 2013) signposted the contamination of surface water due to the improper discharge of untreated domestic and sewage water to the nearby water bodies. (Paranjape, 2013) pointed out the contamination of surface and ground water due to the domestic wastes. The author pointed out that the untreated discharges from various houses arrived into the rivers or other water bodies causing the severe pollution, which in turn lead to the diseases like, Cholera, Typhoid, etc. (Sheeba *et al.*, 2017) highlighted the improper treatment of domestic and sewage wastes for the increased threat of waterborne diseases in the peri-urban areas of Bangalore.

The extensive use of agrochemicals is another source of water pollution. Agro chemicals, like fertilizers and pesticides percolate through the soil and eventually pollute the groundwater resources. The significant agriculture runoff and flooding during monsoon seasons further aggravates the problem. Even though, a large number of studies were conducted in developed nations, only very few studies in India explored this fact. (Mitharwal *et al.*, 2009) demonstrated the agricultural link of the drinking water pollution through their study carried out in Pilani, Rajastan. The authors argued that the increased presence of nitrate in the ground water of the study area was due to the excessive application of chemical fertilizers. (Aulakh *et al.*, 2009) supported this argument by demonstrating a significantly higher concentration of nitrate in the groundwater of farmlands in Punjab. (Mali, 2015) also pointed out the association between agricultural activities and ground water pollution. All these sources (industrial, domestic and agricultural practices) polluted the ground as well as surface water and became the sources of water-borne diseases.

The review of the studies which examined the correlation between drinking water pollution and human health is described in the subsequent section.

*Drinking water pollution and public health*

Drinking water contamination is one of the vital causes that can create potential health problems in human beings. According to the study by WHO, about 2.3 billion people were affected by water related diseases worldwide. The condition is much worse in developing countries, where more than 2.2 million people die every year due to drinking of polluted water and inadequate sanitation. Another alarming statistic reported that water related infective and parasitic diseases account for approximately 60% of infant mortality in the world (Ullah *et al.,* 2009). The statistics and studies indicate that India is one of the prominent nations, where the public health is largely suffered by the consumption of polluted water. Table 1 shows the various diseases caused by poor water and sanitation.

**Table 1.** Water and Sanitation-related Diseases (WHO, 1995).

| Group | Diseases |
|---|---|
| Water-borne diseases (diseases transmitted by water) | Cholera; Typhoid; Bacillary dysentery Infectious hepatitis; Giardiasis |
| Water-washed diseases (caused by lack of water) | Scabies; Skin sepsis and ulcers; Yaws; Leprosy; Lice and thypus; Trachoma; Dysenteries; Ascariasis; Parathphoid |
| Water based diseases | Schistomiasis; Dracunuliasis; Bilharziosis; Filariasis; Threadworm |
| Water-related insect vector diseases | Yellow fever Dengue fever Bancroftian filariasis Malaria Onchocerciasis |

The microbial pollution of drinking water and its adverse health impacts on human beings is one of the severest and prominent health problems in India. The lack of proper sanitation measures in rural India and the improper waste water management in the urban regions is the prime causes for the health problems, like diarrhea in India. A study conducted in the rural Rajasthan indicated this fact (Suthar, 2009).

The authors demonstrated that the polluted drinking water in the study area due to the higher presence of *E. Coli* and *E. aerogenes* can be the possible reasons for the serious diseases, especially in infants. (Mukhopadhyay *et al*., 2012) analyzed the microbial quality of well water in rural and urban Karnataka. The study signposted the presence of higher level of coliform bacteria, moreover, the authors also indicated the presence of multi drug resistant bacteria, which demands the urgent attention, as these pathogens can cause potential health risks. However, in spite of these findings, the study failed in taking adequate samples to verify its health effects in the habitants of the study area. (Sheeba *et al.,* 2017) highlighted the increased threat of waterborne diseases in the peri-urban areas of Bangalore, where they found significantly high composition of E. Coli Bacteria in the drinking water.

The significantly higher concentrations of the minerals like, fluorides, nitrates, phosphates etc. also cause potential health threats to the people living in India. (Susheela, 2007) highlighted the increase in the dental fluorosis among Indians as a result of excessive level fluoride in the drinking water. (Yadav *et al*., 2019) demonstrated that the consumption of fluorides above the desired level causes severe health problems both in infants and adults. The diseases range from dental fluorosis to kidney damage, as well as deformation and degeneration to bones, muscles and nerves.

Another potential threat to human health is the higher composition of toxic metals in the drinking water. These significantly higher concentrations of these metals in the drinking water can lead to fatal medical conditions, such as renal tumor, eyelid edema, fatal lesions in kidneys, cardiovascular diseases, cancer etc. (Solenkova *et al*., 2014).

The authors pointed out the serious genotoxic, carcinogenic and immunotoxic impacts of excessive presence of Chromium. Arsenic is another toxic metal, which can cause severe health problems in human beings. A study carried out in Brahmaputra flood plains in Assam, indicated the potential health threats including the possibility of cancer and fatal impact to kidneys, due to the higher Arsenic concentration in drinking water (Mahanta *et al.,* 2009). The various authors substantiated that the exposure to suggestively higher concentrations of Arsenic through drinking water significantly increases the possibility of lung cancer as well as, the skin and bladder lesions, such as pigmentation changes and hyperkeratosis. However, all these studies focused on the association between public health and heavy metal water pollution in northern and eastern planes, the studies that explored the impact of polluted drinking water on public health in the Deccan plateau region, which is known for widespread agricultural fields and mines. Specifically, the potential health effects due to the excessive radioactive exposure through drinking water were barely studied. Similarly, correlation between the chemical exposure in the drinking water, such as pesticides and human health was also not widely examined and demands more extensive studies.

Water-related disease places an excessive burden on the population and health services of many countries worldwide and in particular those in developing countries. Table 2 shows estimates of the morbidity and mortality rates of some major water-related diseases worldwide, figures which are likely to be conservative estimates. Results of epidemiological studies into the relationship between the quality of water supply and sanitation versus human health vary widely and there are severe methodological difficulties involved in undertaking such studies. Nevertheless, there is sufficient evidence to support the conclusion that improving water supply and sanitation can have a significant impact on human health. Table 3 shows the potential morbidity reductions for multiple diseases as a result of improvements in water supply and sanitation.

**Table 2.** Morbidity and mortality rates of some important water-related diseases (WHO, 2000).

| Diseases | Cases per year (thousands) | Deaths per year (thousands) |
|---|---|---|
| Cholera | 384 | 11 |
| Typhoid | 500 | 25 |
| Giardiasis | 500 | Low |
| Amoebiasis | 48,000 | 110 |
| Diarrhoeal disease | 1,500,000 | 4,000 |
| Ascariasis | 1,000 | 20 |
| Trichuriasis | 100 | Low |
| Ancylostoma | 1,500 | 60 |
| Dracunculiasis (Guinea worm) | >5,000 | - |
| Schistosomiasis | 200,000 | 800 |
| Trachoma | 360,000 (active) | 9,000 (blind) |

**Table 3.** Potential Reductions in Morbidity for Different Diseases as a Result of Improvements in Water Supply and Sanitation (WHO, 1995).

| Diseases | Diseases Projected reduction in morbidity (%) |
|---|---|
| Cholera, thyphoid | 80 - 100 |
| Diarrhoeal diseases, dysentery, gastroenteritis | 40 - 50 |
| Dracunuliasis | 100 |
| Schistosomiasis | 60-70 |

## Conclusions

From the studies, there is a clear dearth of studies which examined the role of anthropogenic activities, specifically agricultural activities, in generating the excessive presence of fluorides in semi-arid lands. The studies regarding the pollution due to heavy metals focused on arsenic, chromium, iron, etc. Very few studies have examined the drinking water contamination due to radioactive metals like uranium. In addition, the majority of the studies regarding the association between heavy metals and water pollution were conducted in North India, especially on the banks of the river Ganga as well as the banks of the Brahmaputra. Only a very few studies targeted the regions in South India, where a large number of mines are actively functioning. The role of human activities in polluting the ground and surface water revealed the dearth of studies which explored the correlation between agricultural activities and ground as well as surface water pollution, specifically in the semi-arid Deccan plateau region, which is famous for various agricultural activities.

Again, even though numerous studies examined the contamination of both surface and groundwater due to the presence of microorganisms, very few substantiated the health problems caused by these pathogens. Additionally, there is also a big gap in exploring the relationship between excessive nitrate levels and health issues. Above all, the studies barely explored the relationship between groundwater availability and pollution. All these gaps mentioned above, along with a clear dearth of studies conducted in the Southern Deccan plateau, which is a popular agricultural region and also a major centre of core mining industries; open the door for further exploration and extensive studies.

**Ethics approval and consent to participate**

Not applicable

**Consent for publication**

Not applicable

**Competing interests**

The authors declare that they have no competing interests

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