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The Impacts on Consumer Health from Dug Well Contamination - A Crucial Drinking Water Source

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Abstract: Main objective of this review is to analyse potential sources of pollution, constituents, consumer health risks related to contaminated drinking water, and remediation strategies. Dug wells with poorly protected well mouth-covering or unlined wells are more susceptible to biological and chemical contamination. Physical irregularities in the lining and covering of the well act as a door to the entry of pollutants into the well. Residential, municipal, commercial, industrial, and agricultural activities can have an impact on ground water quality.

Agriculture is one of the most common human activities that have an impact on both surface and groundwater. Water resource quality is determined by geological characteristics such as soil kinds, topography slope, plant roots, water dissolution with minerals/soils, and the radioactive decay of elements. Septic tanks, pit latrines, and sewer systems are the main source of faecal contamination in the groundwater system. Pesticides, fertilisers, and livestock dung frequently introduce heavy metals into aquifers, posing a direct hazard to human health. Waterborne diseases such as diarrhoea, cholera, syphilis, and typhoid have been linked to a lack of adequate water. Drinking water containing various anions and heavy metals, such as Cd, Cr, Co, Hg, Ni, Pb, Zn, and others, has a substantial negative impact on human health. Drinking water treatment removes impurities from the source water, making it safe to drink. The long-term goal of decontamination is to detect and remove hazardous compounds from water cost-effectively and reliably.

Keywords: Drinking water, Dug well, Ground water, Consumer health, Waterborne disease, Coliforms

I. INTRODUCTION

A pillar of civilization and a necessity for public health is an adequate supply of safe water (Gunnarsdottir *et al*.,2020). Groundwater has been regarded as a reliable source of water for many purposes since prehistoric times, and it is thought to be less resistant to quality (physical and bacteriological) deterioration since it is sealed within the vadose zone envelope. As civilization progressed, human density rose, urbanisation and industry spread, and organised farming expanded rapidly, water quality began to deteriorate. Groundwater is gaining a lot of attention because it has become a key resource for a country's socio-economic development. As a material basis, water resource plays a critical role in the development of the national economy, the geographical distribution of industry, the enhancement of resident living quality, and the security of the regional ecological environment for human survival (Marston and Cai 2016).

There are various sorts of groundwater resources that humans use which include dug wells, boreholes, springs and so on. Boreholes are more difficult to construct and maintain than hand-dug wells, hence hand-dug wells are widespread in the residences of middle and low-income earner's life (Oyebode *et al*., 2015).

The United Nations' Sustainable Development Goals (SDGs) on attaining universal and equitable access to potable water, appropriate sanitation, and hygiene by 2030 were adopted in 2015 (UN General Assembly 2015). Inadequate access to clean water and sanitation is one of the most persistent issues plaguing people all over the world. Although water is essential for human life, well-being, food security, and socioeconomic growth, approximately half of the world's population, in both developed and developing countries, suffers from water contamination (Li *et al*., 2021). Water quality can be considered as a measure of a water's fitness for a specific purpose based on selected physical, chemical, and biological qualities based on standards. Surface water sources are easily contaminated by surface processes. Agricultural, mining, and industrial activity, as well as indiscriminate garbage disposal, are examples of surface processes (Konwea & Ajayi 2021). The precautionary principle, as well as increased consumer knowledge of these risks, has prompted worldwide and national health organisations, as well as government authorities, to regulate and update drinking water quality requirements regularly (Dettori *et al*., 2022). Human health is dependent on the regular availability of safe drinking water, but wells and boreholes are scarce in many developing countries.

II. DUG WELL CONTAMINATION

Due to the rapid growth in world population, scarcity of groundwater is a major concern. Dug well water is mostly used as a drinking water source as it is less polluted water than surface water. Dug wells are more susceptible to the surroundings when they have sources of pollutants like septic tanks adjacent to them. Pollutants can be absorbed by shallow groundwater found in dug wells. Dug wells with poorly protected well mouth-covering or unlined wells are more susceptible to biological and chemical contamination (Pedley and Howard 1997; Howard *et al.*, 2003). The site selection or the construction phase of a well is very important as it can reduce the chance of contamination from surrounding sources. During the construction of a well, a potential source of contamination must be identified and put distance from the source as recommended by the international standards bureaus like WHO and other national standards bureaus. Maintenance and types of mouth casing, covering, internal casing, and surrounding pavements of wells are very important in maintaining the quality of water. Groundwater pollution is also caused by a shortage of suitable land for constructing septic tanks, allowing pollutants to flow with rains to bodies of water in densely populated areas (Putra 2018). The water quality of the well is impacted by a poorly managed landfill site (Finmeta *et al*., 2020; Luo *et al*., 2019)

However, due to physical, chemical, and bacteriological pollution, drilled wells pose a significant risk. Physical irregularities in the lining and covering of the well act as a door to the entry of pollutants into the well. Changes in colour, taste, odour and presence of debris will decrease the quality of water which will turn unfit for drinking purposes. Chemical contaminants such as heavy metals emitted by industries have become one of the most dangerous pollutants in groundwater (Kistan *et al*.,2017). Waterborne pathogens such as bacteria, viruses, protozoa, and helminthic parasites, which offer broad health concerns when consuming untreated or inadequately treated water, are the main concern of biological contamination. These contaminants are deposited in the well water due to seepage of surface water, such as rains (Wolo *et al*.,2020). Contaminated water can lead to bacterial infections, epidemics, and major health problems, as well as social and economic consequences (Emmanual *et al.*, 2009).

Apart from human activity, slope, geological strata, and rainfall all have an impact on water quality (Aryasa *et al*.,2020). Total dissolved solids (TDS) Of well water is mainly due to rock weathering as well as anthropogenic activities. Even though it is not harmful, a high TDS value can cause water turbidity, which means that the photosynthesis process in water bodies is slowed (Wolo *et al*., 2020). Due to the rise in turbidity of the water, rapid growth in pathogens can be found (Weller *et al.*, 2020). Dug well water or groundwater is less likely to be contaminated than surface water, so it is commonly used as drinking water. Contamination of drinking water with various chemicals and heavy metals emitted from various anthropogenic sources has become a global concern (Rapant and Krcmova 2007) Physical, chemical, and bacteriological parameters must be met before drinking water can be consumed. Drinking water that does not meet quality requirements might lead to health concerns.

A. Variations in the Quality of Groundwater with Respect to Depth

The depth and type of well have an impact on groundwater degradation and contamination. Waste dumps, cemeteries, poorly maintained or abandoned wells, and nearby septic tanks are all potential sources of contamination (Jimmy *et al.*, 2013). Studies on the relationship between groundwater quality and depth variation from Delhi, India demonstrate a negative correlation on chemical indicators, which confirms the high salinity of water that is present at lower depths. While population areas had the lowest depth of water from ground level among all the analysed land covers, protected forest area sites had water available at highest depth due to mining activities. Yamuna River is a source of recharge, hence there is reduced depth of groundwater in habitation area sites as a result of high-water extraction (Gupta & Sarma 2013). According to a conducted ground water studies carried out by a team of researchers from Punjab who were pleased with their sampling results during the installation of observation wells, the groundwater quality in the 45–60 m depth range is classified as fit in 53 percent of cases and marginal to unfit in the remaining 47 percent on the basis of electrical conductivity and residual sodium carbonate (Chopra & Krishan 2014). Safer groundwater salinity levels were observed in deep bore wells (>20 m) compared shallow bore wells (20 m), according to another study from groundwater salinity fluctuations at spatiotemporal, depth levels in the Rohtak district, Haryana, India (Kishore *et al.*, 2022). High groundwater salinity affects roughly 1.1 billion people and about 16 percent of the world's geographical area. A common problem in semi-arid and dry areas, heavily irrigated farmland, and groundwater drawn from shallow or intermediate depths is groundwater salinity (Li *et al*., 2020).

III. SOURCES AND ELEMENTS OF GROUNDWATER CONTAMINATION

Groundwater is a major supply of drinking water around the world, contamination by inorganic and organic chemicals, and biological and radiological elements of natural or anthropogenic origin is an important global environmental issue (Rapant and Krcmova 2007). The degradation of groundwater quality can be induced in one of two ways:

Anthropogenic and geogenic. The contamination is referred to as anthropogenic when the primary source and cause of groundwater quality decline is linked to human activities such as municipal, industrial, and agricultural. Those that develop naturally, mostly as a result of rock-water contact is called geogenic.

A. Geogenic Contaminants

The term "geogenic pollution" refers to naturally occurring high concentrations of specific elements in groundwater that have a deleterious impact on human health. Water resource quality is determined by geological characteristics such as soil kinds, topography slope, plant roots, water dissolution with minerals/soils, and the radioactive decay of elements (Schoonover & Crim 2015). Geogenic contamination of groundwater can result from geochemical characteristics of the aquifer material, such as a high concentration of contaminant in the rock matrix dissolved during rock-water interaction, or environmental conditions, such as a wide range of climatic conditions, aquifer redox conditions, and the groundwater flow congestion, all of which make it easier for the contaminant to enter the aqueous phase. Climate change and natural disasters like floods, droughts, and windstorms are all short-term risks that cause infrastructure damage and service disruption to the groundwater system (Howard *et al.* 2016). The chemical components of igneous and sedimentary rocks are most likely to leak from worn and fractured zones into groundwater and surface water through a variety of processes if anthropogenic pollution is not taken into account. Many sources of water cannot be used for drinking as the amount of leached material rises. The fluoride contamination process in the weathered and fractured zones of hard-rock aquifers is influenced by variations in local and regional groundwater circulation (Nakayama *et al*., 2022).

B. Anthropogenic Contaminants

The degradation of groundwater can be by anthropogenic activity such as agricultural practices and waste disposal as well as chemical compounds from various industries. In the anthropogenic environment, the susceptibility of groundwater aquifers and the risk of pollution increases from the complex interplay of the hydrological system's natural dynamics with physical changes to the land surface, human-caused waste discharge, and water resource exploitation (Li *et al.*, 2018). Through topography changes, artificial water bodies development, river channelling, surface sealing, and changes in surface ruggedness, physical landscape changes increase the vulnerability of groundwater systems (Lyon *et al*., 2011). Aside from changes in land use and land cover, the anthropogenic activity includes the widespread use of synthetic and natural chemical compounds (pesticides and fertilisers) (Bellin *et al*., 2020).). Organic compounds can enter community drinking water supplies from a variety of point and non-point sources, including agricultural runoff, artificial recharge, and wastewater treatment plant effluents. Several organic compounds have been found in community drinking water sources around the world recently. Organic compounds such as carbamazepine, atrazine, caffeine, and metolachlor are regularly found in drinking water (Mukhopadhyay *et al*., 2022).

C. Pesticides & Fertilizers

Agriculture is one of the most common human activities that have an impact on both surface and groundwater. Groundwater quality is critical for drinking water production, but pesticide contamination is rapidly threatening groundwater resources. Pesticides and fertilisers are an important part of crop production around the world, yet their use throws potable water at risk. Pesticides used in excess to manage pests and weeds contaminate bodies of water and cause health hazards for consumers (Kalantary *et al*., 2022). Pesticide concentrations in drinking water over 0.1 g/L violate the Drinking Water Directive's rules and pose a major health risk. (Cosgrove *et al*., 2019).

Arsenic is a known carcinogen that is used as lead-arsenate ($PbHAsO_4$) pesticides in fruit tree orchards in different parts of the world. The most common source of arsenic in wells is assumed to be naturally occurring and linked to both bedrock mineralogy and groundwater redox conditions (Gross & Brown, 2020; Yang *et al*., 2015). However, anthropogenic arsenic has a long history of extensive use in agriculture, which could contribute to arsenic in groundwater (Higgins *et al*., 2022). Meanwhile, many commonly used compounds in agriculture are persistent, mobile, and soluble in aquifer systems, posing a threat to human health and the environment (Chaudhary 2020).

Fertilizer components that aren't properly regulated can end up in water bodies through runoff or leaching (Smith & Siciliano 2015). Nitrogen (N) and phosphorus (P) are the two principal fertiliser chemicals that are most dangerous to water resources (P). Nitrate poisoning of water bodies can be caused by improper or excessive fertiliser use. Groundwater contamination with fluoride is a global problem. Fluoride pollution of water resources is a global concern since excessive fluoride in drinking water poses major health hazards (Nizam *et al*., 2022).

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D. Faecal Contamination

The concentration of faecal indicator microorganisms has been proposed as a health risk indicator (Franziska *et al*.,2021). The tendency of downstream urbanisation, the shortest distance between water sources and pit latrines/sewerage systems, raw sewage deep well injection and increased urban, pastures and agricultural runoffs containing human and animal excreta were all potential sources of contamination (Khan *et al.*, 2018). Biological pollutants from nearby sources, such as toilets, underground damaged sewerage pipes, seepage/percolation from drainage systems, and low wastewater treatment plant efficiency, typically cause contamination, which leads to serious disease (Khalid *et al*., 2011). Septic tanks, pit latrines, and sewer systems are the main source of faecal contamination in the groundwater system. A septic tank is a type of subterranean sedimentation tank that is used to treat wastewater through biological breakdown and drainage. Many house owners who also acquire their drinking water from adjacent private wells employ septic tanks as a wastewater treatment alternative. These septic tanks may fail and leak profusely, causing environmental harm and poisoning groundwater (Ojo 2022). Human-specific pathogens such as Shigella, Norovirus, hepatitis A virus, Escherichia coli, Salmonella, and Cryptosporidium, which primarily infect and proliferate in the gastrointestinal tract of the host, can be found in groundwater utilised for daily life (Uyttendaele *et al*.,2015; Callejon *et al*.,2015). The presence of E. coli in drinking water implies that the water sources have been contaminated by the faeces of humans or other warm-blooded animals, and it also suggests the presence of pathogenic organisms. (Pote *et al*., 2009). Water, on the other hand, serves as a passive carrier for a variety of organisms that can cause illness in humans, including viruses, protozoa, and bacteria. (Ali *et al*., 2017, Cui *et al*., 2017).

E. Heavy Metals

High concentrations of heavy metals contamination from anthropogenic (e.g., mining, wastewater, irrigation, industry, and agriculture) and natural resources (e.g., erosion of bedrocks and volcanic eruptions processes) harm groundwater quality (Mirzabeygi *et al*.,2017). Heavy metal pollution of groundwater, defined as metals with concentrations more than 5 g/cm3, is a difficult and pressing issue (Liu *et al*.,2021; Yan *et al*.,2019). Agricultural activities are one of the main sources of heavy metal pollution in groundwater. Heavy metals infiltrate the soil in agricultural areas when huge amounts of fertiliser, insecticides, and other agricultural production chemicals are utilised (Wu *et al*., 2020). Leaching and osmosis can allow heavy metals in the soil to enter groundwater. Heavy metals in excess can be harmful to the environment and human health (Dehghani *et al*., 2022). Pesticides, fertilisers, and livestock dung frequently introduce heavy metals into aquifers, posing a direct hazard to human health (Li *et al*., 2020; Li *et al*.,2018). Heavy metals from a variety of sources find their way into groundwaters like Manganese is found in the groundwater via sewage sludge and municipal wastewater discharges (WHO, 2004). Likely Vehicle exhausts, pesticides, engine leakage, and Cadmium-containing dust are all possible sources of Cadmium in water (Malassa *et al*., 2014). Leakage, poor storage, and inappropriate industrial waste disposal techniques have all been shown to release Cr into the environment (Ojo 2022). Fe (iron) can enter the groundwater system through coagulating chemicals used in water treatment facilities and when steel, cast iron, and galvanised iron pipes are used for water distribution, and it can be fatal if taken in concentrations of 200 to 250 mg/kg of body weight (WHO, 2003b).

Table I. Key elements of ground water pollution and their health risk

Pollutant	Source	Human health problem	Reference
Fluoride	Rock weathering, Industrial waste	Skeletal fluorosis Dental fluorosis	WHO 2019, Nizam *et al*.,2022, Solanki *et al*., 2022.
Nitrate	Fertilizers, livestock, septic tanks	Methemoglobinemaia	Sunitha *et al*.,2022 Singh *et al*.,2022
Phosphorous, Chloride, Sulphate,	Fertilizer, Pesticides, Treatment system,	Catharsis, Dehydration, Gastrointestinal and digestive disorders	WHO 2010, Annan *et al*.,2022.
Heavy Metals Manganese Cadmium Iron Arsenic Chromium	Mining, Wastewater, Irrigation, Industry, Agriculture, Water distribution system Naturally occurring bed rock minerology & Groundwater redox condition	Cancer, Infertility, Organ damage, Bone loss, Tooth corrosion, Anaemia, intestinal Bleeding, Cramping, liver and kidney damage	Mirzabeygi *et al*.,2017, Malassa *et al*., 2014, Emokpae and Oyakhire 2020, Gross & Brown, 2020, Yang *et al*., 2015, Nta *et al*., 2018, Xu *et al*.,2020.

IV. CONSUMER HEALTH RISK ON WATER QUALITY

Water's physical, chemical, biological, and aesthetic features are used to describe its quality and determine its suitability for a range of purposes, including human health and aquatic environment protection. (Luvhimbi *et al*.,2022). Water quality has been linked to health outcomes across the world contamination of groundwater can harm human health (Peiyui *et al.*, 2021). Mostly drinking water is supplied through pipelines from a treatment plant. Public water supply is very sensitive due to its long channel distribution. Physical loads, microbiological loads, and nutrient loads all enter the distribution system with treated drinking water (Liu *et al.*, 2014; Prest *et al.*, 2016).

Despite this, inadvertent waterborne illness outbreaks continue to occur in affluent communities due to a lack of awareness of the possible risks and insufficient training of workers and management working on drinking water systems (Ashbolt 2015). Even with well-maintained drinking-water treatment systems, there is growing worried that aged drinking water distribution systems are more susceptible to mains breaks/repairs and associated pressure losses, which could result in pathogen incursion scenarios. (Ebacher *et al*., 2012).

Toxic metal poisoning in drinking water poses a health concern to people and has been linked to a variety of chronic health problems, including cancer, infertility, and organ damage (Emokpae and Oyakhire 2020). The water of poor quality can cause bone loss, tooth corrosion, anaemia, and kidney disease due to the presence of very toxic heavy metal metals and their accumulation in the kidneys (Maru *et al.*,2018). Chromium (Cr) ingestion below 0.1 mg/L may provide some health benefits, but excessive Chromium consumption might result in diarrhoea, stomach and intestinal bleeding, cramping, and liver and kidney damage. (WHO, 2003a). Cadmium (Cd) poisoning can cause renal, bone, and lung damage if you are exposed to too much of it. Similarly, drinking Cd-contaminated water can cause metal poisoning and hormonal abnormalities, which can lead to more serious problems like kidney failure and cancer (Nta *et al.*, 2020).

People who drink water with high levels of Mn for lengthy periods may lose their memory and motor skills. In particular, infants who drink water containing high levels of Mn may suffer educational and behavioural issues (WQP, 2021). Although zinc is an essential vitamin for human growth and development, it can produce stomach cramps, nausea, and vomiting when consumed in large quantities (Damodharan, 2013).

In rural areas of most developing countries, where water supplies are communally shared, bacterial contamination of drinking water is a major contributor to water-borne disorders. The US Environmental Protection Agency has identified over 500 waterborne pathogens of potential concern in drinking water (EPA). Between 2030 and 2050, the World Health Organization (WHO) forecasts that climate change would cause an additional 48,000 deaths from diarrhoea (WHO, 2014), with 60 per cent of diarrhoea deaths in low- and middle-income countries now related to inadequate water, sanitation, and hygiene. (Prüss-Ustün *et al.* 2019). Bacteria and viruses can be found in human sewage and animal waste all over the surface of our globe. People who drink water contaminated with germs may get stomach problems and infections. In developing nations, faecal contamination of water with the hepatitis A and E viruses (HAV and HEV) is a major public health concern (Arora *et al.*, 2013). Diarrhoea is the most common sickness caused by ingesting pathogen-contaminated water via the faecal-oral pathway (WHO). One of the most prevalent diseases affecting people is acute gastroenteritis, which has a higher morbidity and mortality rate in young children and the elderly than in any other age group (Jain & Jain 2014).

Due to poor personal hygiene, hazardous water supplies, and poor sanitation, giardiasis is more common among residents in densely crowded locations like slums and prisons (Roshidi et al., 2021). Rainfall and snowmelt run-off can contaminate private wells by washing bacteria into the system or seeping beneath. Microorganisms can be found in water wells due to waste leakage from subterranean storage tanks and effluent from septic leach fields reaching a water source (USEPA). The presence of coliform bacteria in drinking water, specifically E. coli (a kind of coliform bacteria), signals that the water may include pathogens that cause diarrhoea, vomiting, cramps, nausea, headaches, fever, exhaustion, and even death.

Pathogens in drinking water are more likely to affect infants, children, the elderly, and persons with compromised immune systems (Gwimbi *et al.*, 2019). Vibrio cholerae was discovered to be present in 8 out of 11 deep ground water samples taken from various areas in Central India (Tamrakar *et al*.,2009). Particularly in small communities and underdeveloped nations, where groundwater is frequently the preferred supply of drinking water, the microbial pollution of groundwater has deep and severe repercussions for public health. A major problem for protecting public health and groundwater purity is the excreta's disposal through land-based systems. In peri-urban settings, using ineffective sanitation and water delivery methods puts the public's health at serious and ongoing risk. (Pedley & howard 1997).

Table II
Microbes and their associated waterborne disease

Microbes		Disease	Reference
Bacteria	Vibrio cholera	Cholera	Tamrakar *et al*.,2009
	Escherichia coli	Diarrhoea	Wang *et al*., 2022
	Salmonella typhi	Typhoid fever	Kabwama *et al*.,2017
	Entamoeba histolytica	Amebiasis	Singh *et al*.,2014
Virus	Hepatitis (A, B, C, D &E)	Hepatitis	Arora *et al*., 2013
	Noroviruses, rotavirus	Gastroenteritis	Jain & Jain 2014
Protozoans	*Giardia intestinalis*	Giardiasis	Roshidi *et al*., 2021

Chemical contaminants in water, such as fluoride, nitrates, arsenic, lead, and other heavy metals, can have negative health impacts in addition to microbial pollution (Pruss-Ustun *et al*. 2008). Most of the components present in the water are essential but it is harmful when it is taken in excess. The most significant biological function of nitrite is its role in the conversion of normal haemoglobin to methaemoglobin, which is incapable of transporting oxygen to the tissues. Recently, nitrates have drawn a lot of interest from researchers because of their long history of contaminating surface and groundwater systems with pollutants from the environment. Nitrates that are released into water bodies in greater than necessary amounts have accumulative effects on other living things, and human health as they move up the food chain (Singh *et al*.,2022). The most common human health hazard connected with nitrate ingestion is methemoglobinemia caused by nitrate-derived nitrite. Higher chloride levels in water may not be harmful to human health, but the effect is dependent on the related cation, such as sodium, calcium, magnesium, and potassium (Annan *et al*.,2022). Sulphate concentrations greater than 250 mg/l, according to the WHO, should be notified to health authorities since they might cause catharsis, dehydration, and gastrointestinal and digestive disorders (WHO, 2010). Organic compounds like carbamazepine, atrazine, and caffeine, are known to pose a severe risk to human health in these contaminated water ingesting communities (Mukhopadhyay *et al*., 2022)Dental fluorosis, skeletal fluorosis, arthritis, bone damage, osteoporosis, muscular damage, weariness, joint-related difficulties, and chronicle issues can all be caused by high levels of fluoride ions in drinking water (Solanki *et al*., 2022). Chronic exposure to arsenic harms several organ systems and has been linked to diabetes, hypertension, peripheral blood vessel problems, skin, bladder, kidney, and lung malignancies among other cancers (Xu *et al*.,2020). Studies by (Pinchoff *et al*.,2022) discovered a direct link between arsenic, Recurrent pregnancy loss and infertility.

V. DRINKING WATER REMEDIATION

According to the World Health Organization (WHO), infectious diseases linked to contaminated water and poor sanitation are a leading cause of death and disease in both low- and middle-income nations, particularly among children under the age of five (Mills & Cumming 2016). Industrial pollution, agricultural residue, and untreated wastewater threaten the quality of useable water. Groundwater consumption and well drilling in unsuitable conditions raise the risk of contamination, which can be caused by anthropogenic or natural activity. Due to a lack of groundwater quality monitoring and rules governing well drilling, the population consumes water that has not been properly treated. Water consumption without sufficient quality control is a public health concern since it is frequently used as a vehicle for disease transmission (Maran *et al*., 2016). Groundwater is found in underground geological strata, clean-up is difficult and expensive once it has been contaminated (Wang *et al*.,2020) Drinking water treatment removes impurities from the source water, making it safe to drink.

Different methods and their combinations can be utilised for drinking water production depending on the contaminants present. The long-term goal of decontamination is to detect and remove hazardous compounds from water cost-effectively and reliably. Arsenic, heavy metals, halogenated aromatics, nitrosamines, nitrates, phosphates, and other widely spread compounds are known to affect humans and the environment. One overarching goal for delivering safe water is to disinfect water from traditional and emerging pathogens in a cost-effective and resilient manner, without causing additional problems as a result of the disinfection process. Contamination of groundwater by residual organic micropollutants such as pesticide residues poses a danger to drinking water quality. Activated carbon block filters for removing chemical pollutants from well water have also been tested in prior studies. Microbial pollutants cannot be eliminated by activated carbon block filters (Mulhern *et al*.,2021). Bioaugmentation with specialised pollutant-degrading bacteria is one technique to treat drinking water containing micropollutants. Rapid sand filters are reported to have a large variety of bacteria that may be able to digest some organic micropollutants.

Reverse osmosis (RO) is a well-known membrane separation process for creating clean water by rejecting and concentrating organic micropollutants such as pesticide residues and inorganic nutrients in a lower volume 'trash' stream (Fini *et al.*, 2020). (Schostag *et al*.,2022). A particularly promising technique for cleaning up organically-polluted water is cold plasma (Aggelopoulos 2022). Biopolymers are adsorbents in the removal of environmental pollutants. Biopolymers are appealing environmentally friendly materials for water treatment systems because they are renewable, biocompatible, and biodegradable (Lustenberger *et al*., 2022). Groundwater pollution levels must be predicted and monitored on a regular and ongoing basis.

VI. CONCLUSION

Groundwater has been regarded as a reliable source of water for various purposes because it is sealed within the vadose zone envelope of the earth. People in lower-income communities in developing countries drink directly from groundwater sources, without any treatment or assessment of the water's purity. Researchers from all over the world have identified a variety of sources and materials that contaminate the groundwater resource. In the realm of remediation research and decontamination techniques, identifying potential sources of contamination is critical. Pollutants include microbes, heavy metals, chemicals, and other trace elements which originated from both geogenic and anthropogenic activities. Numerous sources of pollutants may provide chronic minor and major health risks to people of various ages. To avoid a pandemic of water-borne diseases, effective testing and monitoring by respected agencies, as well as well-planned policymaking, are essential.

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REFERENCES

[1] Aggelopoulos, C. A. (2022). Recent advances of cold plasma technology for water and soil remediation: A critical review. Chemical Engineering Journal, 428, 131657.
[2] Ali, J., Ali, N., Jamil, S. U. U., Waseem, H., Khan, K., & Pan, G. (2017). Insight into eco-friendly fabrication of silver nanoparticles by Pseudomonas aeruginosa and its potential impacts. Journal of environmental chemical engineering, 5(4), 3266-3272.
[3] Annan, S. T., Frimpong, B., Owusu-Fordjour, C., & Boasu, B. Y. (2022). Assessing Localized Contamination Hazard and Groundwater Quality Challenges in Water-Stressed Peri-Urban Accra, Ghana. Journal of Geoscience and Environment Protection, 10(1), 13-28.
[4] Arora, D., Jindal, N., Shukla, R. K., & Bansal, R. (2013). Water borne hepatitis a and hepatitis e in malwa region of punjab, India. Journal of clinical and diagnostic research: JCDR, 7(10), 2163.
[5] Aryasa, I. W. T., Risky, D. P., & Artaningsih, N. P. L. J. (2020). UJI PENDAHULUAN KUALITAS AIR PADA SUMBER MATA AIR DI BANJAR TANGGAHAN TENGAH, DESA SUSUT KECAMATAN SUSUT KABUPATEN BANGLI. Jurnal Kesehatan Terpadu, 3(2), 76-81.
[6] Ashbolt, N. J. (2015). Microbial contamination of drinking water and human health from community water systems. Current environmental health reports, 2(1), 95-106.
[7] Bellin, A., Fiori, A., & Dagan, G. (2020). Equivalent and effective conductivities of heterogeneous aquifers for steady source flow, with illustration for hydraulic tomography. Advances in Water Resources, 142, 103632.
[8] Callejón, R. M., Rodríguez-Naranjo, M. I., Ubeda, C., Hornedo-Ortega, R., Garcia-Parrilla, M. C., & Troncoso, A. M. (2015). Reported foodborne outbreaks due to fresh produce in the United States and European Union: trends and causes. Foodborne pathogens and disease, 12(1), 32-38.
[9] Chaudhary, J. K. (2020). A comparative study of fuzzy logic and WQI for groundwater quality assessment. Procedia Computer Science, 171, 1194-1203.
[10] Chopra, R. P. S., & Krishan, G. (2014). Assessment of groundwater quality in Punjab, India. Earth Sci Clim Change, 5(10).
[11] Cosgrove, S., Jefferson, B., & Jarvis, P. (2019). Pesticide removal from drinking water sources by adsorption: a review. Environmental Technology Reviews, 8(1), 1-24.
[12] Cui, Q., Fang, T., Huang, Y., Dong, P., & Wang, H. (2017). Evaluation of bacterial pathogen diversity, abundance and health risks in urban recreational water by amplicon next-generation sequencing and quantitative PCR. Journal of Environmental Sciences, 57, 137-149.
[13] Damodharan, U. (2013). Bioaccumulation of Heavy Metals in Contaminated River Water-Uppanar, Cuddalore, South East Coast of India, Perspectives in Water Pollution, Imran Ahmad and Mithas Ahmad Dar, IntechOpen books.
[14] Dehghani, M., Gharehchahi, E., Jafari, S., Moeini, Z., Derakhshan, Z., Ferrante, M., & Conti, G. O. (2022). Health risk assessment of exposure to atrazine in the soil of Shiraz farmlands, Iran. Environmental Research, 204, 112090.
[15] Dettori, M., Arghittu, A., Deiana, G., Castiglia, P., & Azara, A. (2022). The revised European Directive 2020/2184 on the quality of water intended for human consumption. A step forward in risk assessment, consumer safety and informative communication. Environmental Research, 112773.
[16] Ebacher, G., Besner, M. C., Clément, B., & Prévost, M. (2012). Sensitivity analysis of some critical factors affecting simulated intrusion volumes during a low pressure transient event in a full-scale water distribution system. Water Research, 46(13), 4017-4030.
[17] Emmanuel, E., Pierre, M. G., & Perrodin, Y. (2009). Groundwater contamination by microbiological and chemical substances released from hospital wastewater: Health risk assessment for drinking water consumers. Environment international, 35(4), 718-726.
[18] Emokpae, M. A., & Oyakhire, F. O. (2020). Levels of some reproductive hormones, cadmium and lead among fuel pump attendants in Benin City, Nigeria. African Journal of Medical and Health Sciences, 19(6), 70-77.
[19] Finmeta, A. W., Bunyani, N. A., & Naisanu, J. (2020). Keberadaan tempat pembuangan akhir berdampak pada kualitas air. Jurnal Biologi Tropis, 20(2), 211-218.

[20] Gross, E. L., & Brown, C. J. (2020). Arsenic and uranium occurrence in private wells in Connecticut, 2013–18—a spatially weighted and bedrock geology assessment (No. 2020-1111). US Geological Survey.
[21] Gunnarsdottir, M. J., Gardarsson, S. M., Schultz, A. C., Albrechtsen, H. J., Hansen, L. T., Bergkvist, K. S. G., ... & Bartram, J. (2020). Status of risk-based approach and national framework for safe drinking water in small water supplies of the Nordic water sector. International Journal of Hygiene and Environmental Health, 230, 113627.
[22] Gupta, P., & Sarma, K. (2013). Evaluation of groundwater quality and depth with respect to different land covers in Delhi, India. International Journal of Applied Sciences and Engineering Research, 2(6), 630-643.
[23] Gwimbi, P., George, M., & Ramphalile, M. (2019). Bacterial contamination of drinking water sources in rural villages of Mohale Basin, Lesotho: exposures through neighbourhood sanitation and hygiene practices. Environmental health and preventive medicine, 24(1), 1-7.
[24] Higgins, M. A., Metcalf, M. J., & Robbins, G. A. (2022). Nonpoint source arsenic contamination of soil and groundwater from legacy pesticides (Vol. 51, No. 1, pp. 66-77).
[25] Howard, G., Calow, R., Macdonald, A., & Bartram, J. (2016). Climate change and water and sanitation: likely impacts and emerging trends for action. Annual review of environment and resources, 41(1), 253-276.
[26] Jain, P., & Jain, A. (2014). Waterborne viral gastroenteritis: an introduction to common agents. In Water and Health (pp. 53-74). Springer, New Delhi.
[27] Jimmy, D. H., Sundufu, A. J., Malanoski, A. P., Jacobsen, K. H., Ansumana, R., Leski, T. A., ... & Stenger, D. A. (2013). Water quality associated public health risk in Bo, Sierra Leone. Environmental monitoring and assessment, 185(1), 241-251.
[28] Kabwama, S. N., Bulage, L., Nsubuga, F., Pande, G., Oguttu, D. W., Mafigiri, R., ... & Zhu, B. P. (2017). A large and persistent outbreak of typhoid fever caused by consuming contaminated water and street-vended beverages: Kampala, Uganda, January–June 2015. BMC public health, 17(1), 1-9.
[29] kalantary, R. R., Barzegar, G., & Jorfi, S. (2022). Monitoring of pesticides in surface water, pesticides removal efficiency in drinking water treatment plant and potential health risk to consumers using Monte Carlo simulation in Behbahan City, Iran. Chemosphere, 286, 131667.
[30] Khan, K., Lu, Y., Saeed, M. A., Bilal, H., Sher, H., Khan, H., ... & Liang, R. (2018). Prevalent fecal contamination in drinking water resources and potential health risks in Swat, Pakistan. Journal of Environmental Sciences, 72, 1-12.
[31] Kishor, K., Patel, M., Bhattacharya, P., Pittman Jr, C. U., & Mohan, D. (2022). Sources, spatio-temporal distribution and depth variations in groundwater salinity of semi-arid Rohtak district, Haryana, India. Groundwater for Sustainable Development, 100790.
[32] Kistan, A., Anandan, V. A. V., & Ansari, A. T. (2017). Investigation on chemical contamination in bore well, dug well and Palar River water near tannery locality of Vellore district, India. International Journal for Research in Applied Science and Engineering Technology, 5(10), 802-815.
[33] Konwea, C. I., & Ajayi, O. (2021). Effectiveness of Different Hand-Dug Well Treatment Methods in a Typical Basement Complex Environment. Journal of Mining and Geology, 57(2), 331-337.
[34] Li, H., Yu, X., Zhang, W., Huan, Y., Yu, J., & Zhang, Y. (2018). Risk assessment of groundwater organic pollution using hazard, intrinsic vulnerability, and groundwater value, Suzhou City in China. Exposure and Health, 10(2), 99-115.
[35] Li, J., Song, L., Chen, H., Wu, J., & Teng, Y. (2020). Source apportionment of potential ecological risk posed by trace metals in the sediment of the Le'an River, China. Journal of Soils and Sediments, 20(5), 2460-2470.
[36] Li, P. Y., Karunanidhi, D., Subramani, T., & Srinivasamoorthy, K. (2021). Sources and Consequences of Groundwater Contamination. Archives of Environmental Contamination and Toxicology, 80, 1-10.
[37] Li, Q., Yang, J., Fan, W., Zhou, D., Wang, X., Zhang, L., ... & Crittenden, J. C. (2018). Different transport behaviors of Bacillus subtilis cells and spores in saturated porous media: Implications for contamination risks associated with bacterial sporulation in aquifer. Colloids and surfaces B: Biointerfaces, 162, 35-42.
[38] Liu, G., Bakker, G. L., Li, S., Vreeburg, J. H. G., Verberk, J. Q. J. C., Medema, G. J., ... & Van Dijk, J. C. (2014). Pyrosequencing reveals bacterial communities in unchlorinated drinking water distribution system: an integral study of bulk water, suspended solids, loose deposits, and pipe wall biofilm. Environmental Science & Technology, 48(10), 5467-5476.
[39] Liu, Y., Wang, P., Gojenko, B., Yu, J., Wei, L., Luo, D., & Xiao, T. (2021). A review of water pollution arising from agriculture and mining activities in Central Asia: Facts, causes and effects. Environmental Pollution, 291, 118209.
[40] Luo, P., Kang, S., Zhou, M., Lyu, J., Aisyah, S., Binaya, M., ... & Nover, D. (2019). Water quality trend assessment in Jakarta: A rapidly growing Asian megacity. PloS one, 14(7), e0219009.
[41] Lustenberger, S., & Castro-Muñoz, R. (2022). Advanced biomaterials and alternatives tailored as membranes for water treatment and the latest innovative European water remediation projects: A review. Case Studies in Chemical and Environmental Engineering, 100205.
[42] Luvhimbi, N., Tshitangano, T. G., Mabunda, J. T., Olaniyi, F. C., & Edokpayi, J. N. (2022). Water quality assessment and evaluation of human health risk of drinking water from source to point of use at Thulamela municipality, Limpopo Province. Scientific Reports, 12(1), 1-17.
[43] Lyon, S. W., Grabs, T., Laudon, H., Bishop, K. H., & Seibert, J. (2011). Variability of groundwater levels and total organic carbon in the riparian zone of a boreal catchment. Journal of Geophysical Research: Biogeosciences, 116(G1).
[44] Malassa, H., Hadidoun, M., Al-Khatib, M., Al-Rimawi, F., & AlQutob, M. (2014). Assessment of Groundwater Pollution with Heavy Metals in North West Bank Palestine by ICP-MS. Journal of Environment Protection, 5, 54-59
[45] Maran, N. H., Crispim, B. D. A., Iahnn, S. R., Araújo, R. P. D., Grisolia, A. B., & Oliveira, K. M. P. D. (2016). Depth and well type related to groundwater microbiological contamination. International journal of environmental research and public health, 13(10), 1036.
[46] Marston, L., & Cai, X. (2016). An overview of water reallocation and the barriers to its implementation. Wiley Interdisciplinary Reviews: Water, 3(5), 658-677.
[47] Maru, R., Baharuddin, I. I., Badwi, N., & Nyompa, S. (2018, February). Analysis of Water Well Quality Drilling Around Waste Disposal Site in Makassar City Indonesia. In Journal of Physics: Conference Series (Vol. 954, No. 1, p. 012025). IOP Publishing.
[48] Mills, J. E., & Cumming, O. (2016). The impact of water, sanitation and hygiene on key health and social outcomes. Sanitation and Hygiene Applied Research for Equity (SHARE) and UNICEF, 112.
[49] Mukhopadhyay, A., Duttagupta, S., & Mukherjee, A. (2022). Emerging Organic Contaminants in Global Community Drinking Water Sources and Supply: A Review of Occurrences, Processes and Removal. Journal of Environmental Chemical Engineering, 107560.

[50] Mulhern, R., Stallard, M., Zanib, H., Stewart, J., Sozzi, E., & Gibson, J. M. (2021). Are carbon water filters safe for private wells? Evaluating the occurrence of microbial indicator organisms in private well water treated by point-of-use activated carbon block filters. International Journal of Hygiene and Environmental Health, 238, 113852.
[51] Nakayama, H., Yamasaki, Y., & Nakaya, S. (2022). Effect of hydrogeological structure on geogenic fluoride contamination of groundwater in granitic rock belt in Tanzania. Journal of Hydrology, 128026.
[52] Nizam, S., Virk, H. S., & Sen, I. S. (2022). High levels of fluoride in groundwater from Northern parts of Indo-Gangetic plains reveals detrimental fluorosis health risks. Environmental Advances, 8, 100200.
[53] Nta, S. A., Ayotamuno, M. J., Igoni, A. H., Okparanma, R. N. & Udo, S. O. (2020). Application of hazard quotient for the assessment of potential health risk of groundwater users around Uyo main dumpsite. Asian Journal of Advanced Research and Report, 6(1), 49–54.
[54] Ojo, O. M. (2022). Heavy Metal Pollution Levels of Hand-dug Wells in Close Proximity to Septic Tanks.
[55] Oyebode, O.J., Oyegoke, S.O., Olowe, K.O., Onoh, P. and Adebayo, V.B. (2015). Borehole Drilling, Usage, Maintenance and Sustainability in AdoEkiti, Nigeria. American Journal of Engineering R e s e a r c h , 4 (9) , p p . 1 – 1 2 .
[56] Pedley, S., & Howard, G. (1997). The public health implications of microbiological contamination of groundwater. Quarterly Journal of Engineering Geology and Hydrogeology, 30(2), 179-188.
[57] Peiyui, L., Karunamdihi D., & Srinivasamoorthy, K. (2021). Sources and Consequences of Groundwater Contamination. Archives of Environmental Contamination and Toxicology, 80, 1-10
[58] Pinchoff, J., Monseur, B., Desai, S., Koons, K., Alvero, R., & Hindin, M. J. (2022). Is living in a region with high groundwater arsenic contamination associated with adverse reproductive health outcomes? An analysis using nationally representative data from India. International Journal of Hygiene and Environmental Health, 239, 113883.
[59] Prest, E. I., Hammes, F., van Loosdrecht, M., & Vrouwenvelder, J. S. (2016). Biological stability of drinking water: controlling factors, methods, and challenges. Frontiers in microbiology, 7, 45.
[60] Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., Cumming, O., Freeman, M. C., ... & Johnston, R. (2019). Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: an updated analysis with a focus on low-and middle-income countries. International journal of hygiene and environmental health, 222(5), 765-777.
[61] Putra, C. M. M. (2018). The Physical And Microbiological Quality Of Clean Water In Nanas Sub Village Kediri District Post Natural Phenomena Sinking Wells. Jurnal Kesehatan Lingkungan, 10(4), 36-367.
[62] Rapant, S., & Krčmová, K. (2007). Health risk assessment maps for arsenic groundwater content: application of national geochemical databases. Environmental Geochemistry and Health, 29(2), 131-141.
[63] Roshidi, N., Hassan, N. H. M., Hadi, A. A., & Arifin, N. (2021). Current state of infection and prevalence of giardiasis in Malaysia: a review of 20 years of research. PeerJ, 9, e12483
[64] Schoonover, J. E., & Crim, J. F. (2015). An introduction to soil concepts and the role of soils in watershed management. Journal of Contemporary Water Research & Education, 154(1), 21-47.
[65] Schostag, M. D., Gobbi, A., Fini, M. N., Ellegaard-Jensen, L., Aamand, J., Hansen, L. H., ... & Albers, C. N. (2022). Combining reverse osmosis and microbial degradation for remediation of drinking water contaminated with recalcitrant pesticide residue. Water Research, 216, 118352.
[66] Singh, P. P., & Galhotra, A. (2014). Water, Amoebiasis and Public Health. In Water and Health (pp. 169-177). Springer, New Delhi.
[67] Singh, S., Anil, A. G., Kumar, V., Kapoor, D., Subramanian, S., Singh, J., & Ramamurthy, P. C. (2022). Nitrates in the environment: A critical review of their distribution, sensing techniques, ecological effects and remediation. Chemosphere, 287, 131996.
[68] Smith, L. E., & Siciliano, G. (2015). A comprehensive review of constraints to improved management of fertilizers in China and mitigation of diffuse water pollution from agriculture. Agriculture, Ecosystems & Environment, 209, 15-25.
[69] Solanki, Y. S., Agarwal, M., Gupta, A. B., Gupta, S., & Shukla, P. (2022). Fluoride occurrences, health problems, detection, and remediation methods for drinking water: A comprehensive review. Science of the Total Environment, 807, 150601.
[70] Sunitha, V., Reddy, Y. S., Suvarna, B., & Reddy, B. M. (2022). Human health risk assessment (HHRA) of fluoride and nitrate using pollution index of groundwater (PIG) in and around hard rock terrain of Cuddapah, AP South India. Environmental Chemistry and Ecotoxicology, 4, 113-123.
[71] Tamrakar, A. K., Jain, M., Goel, A. K., Kamboj, D. V., & Singh, L. (2009). Characterization of Vibrio cholerae from deep ground water in a cholera endemic area in Central India. Indian journal of microbiology, 49(3), 271-275.
[72] USEPA. 1985. Test methods for Escherichia coli and enterococci in water by the membrane filter procedure (Method #1103.1). EPA 600/4-85-076. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH.
[73] Uyttendaele, M., Jaykus, L. A., Amoah, P., Chiodini, A., Cunliffe, D., Jacxsens, L., ... & Rao Jasti, P. (2015). Microbial hazards in irrigation water: standards, norms, and testing to manage use of water in fresh produce primary production. Comprehensive Reviews in Food Science and Food Safety, 14(4), 336-356.
[74] Wang, D., Wu, J., Wang, Y., & Ji, Y. (2020). Finding high-quality groundwater resources to reduce the hydatidosis incidence in the Shiqu County of Sichuan Province, China: analysis, assessment, and management. Exposure and Health, 12(2), 307-322.
[75] Wang, P., Asare, E., Pitzer, V. E., Dubrow, R., & Chen, K. (2022). Associations between long-term drought and diarrhea among children under five in low-and middle-income countries. Nature communications, 13(1), 1-10.
[76] Water Quality Products (WQP) (2021). Montrose, Minnesota, Finds elevated levels of Manganese in Drinking Water.
[77] Weller, D., Brassill, N., Rock, C., Ivanek, R., Mudrak, E., Roof, S., ... & Wiedmann, M. (2020). Complex interactions between weather, and microbial and physicochemical water quality impact the likelihood of detecting foodborne pathogens in agricultural water. Frontiers in microbiology, 11, 134.
[78] WHO (2010). World Health Organization Guideline for Drinking Water Quality. WHO Summit.
[79] WHO (2019) https://www.who.int/teams/environment-climate-change-and-health/chemical-safety-and-health/health-impacts/chemicals/inadequate-or-excess-fluoride
[80] Wolo, D., Rahmawati, A. S., Priska, M., & Damopolii, I. (2020). Study of dug well water quality in Labuan Bajo, Indonesia. Jurnal Biologi Tropis, 20(3), 432-437.
[81] World Health Organization, WHO., & World Health Organisation Staff. (2004). Guidelines for drinking-water quality (Vol. 1). World Health Organization.

[82] World Health Organization. (2003a). Chromium in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality.
[83] World Health Organization. (2003b). Iron in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality.
[84] World Health Organization. (2014). Preventing diarrhoea through better water, sanitation and hygiene: exposures and impacts in low-and middle-income countries. In Preventing diarrhoea through better water, sanitation and hygiene: exposures and impacts in low-and middle-income countries.
[85] Wu, J., Liu, J., Pan, Z., Wang, B., & Zhang, D. (2020). Spatiotemporal distributions and ecological risk assessment of pharmaceuticals and personal care products in groundwater in North China. Hydrology Research, 51(5), 911-924.
[86] Yan, X., Dong, W., An, Y., & Lu, W. (2019). A Bayesian-based integrated approach for identifying groundwater contamination sources. Journal of Hydrology, 579, 124160.
[87] Yang, Q., Culbertson, C. W., Nielsen, M. G., Schalk, C. W., Johnson, C. D., Marvinney, R. G., ... & Zheng, Y. (2015). Flow and sorption controls of groundwater arsenic in individual boreholes from bedrock aquifers in central Maine, USA. Science of The Total Environment, 505, 1291-1307.