GROUNDWATER CONTAMINATION AND POTENTIAL HEALTH EFFECTS

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ABSTRACT

Groundwater is often used as a source of water supply. This water is often contaminated by inorganic, organic and microbiological substances in the water. These materials find themselves into groundwater through different sources. They make the water unfit for different uses due to their presence in the water in varying quantities leading to health problems, if found in humans above tolerable limits. Groundwater is contaminated by natural impurities or by human activities. This study examines the contaminants, their sources to groundwater and the potential health effects. It is recommended that groundwater be monitored periodically and treated before use, if pollutants are found to exist above tolerable levels to ensure that it is fit for its intended purpose.

Keywords: Groundwater, potential health effects, contaminants, human activities, natural impurities.

1. Introduction

Groundwater is a resource found under the earth's surface. Most groundwater comes from rain and melting snow soaking into the ground. Water fills the spaces between rocks and soils, making an "aquifer". Most drinking water comes from groundwater. Most is supplied through public drinking water system.

Depth of groundwater from surface, its quality for drinking and chance of being polluted varies from place to place. Generally, the deeper the well, the better the groundwater. The amount of new water flowing into the area also affects the groundwater quality.

Groundwater may contain some natural impurities or contaminants, even with no human activities or pollution. Natural contaminants can come from many conditions in the water shed or in the ground. Water moving through underground rocks or soils may pick up magnesium, calcium and chlorides. Some ground water naturally contains dissolved elements such as; arsenic, boron, selenium or radon, a gas formed by the natural breakdown of radioactive uranium in soil. These natural contaminants are health problems if presents above tolerable limits.

In addition to natural contaminants, groundwater is often polluted by human activities such as;

- Improper use of fertilizers animal manures, herbicides and pesticides.
- Improperly built or poorly located or maintained septic systems for household water.
- Leaking or abandoned underground storage tanks and piping.
- Storm-water drains that discharge chemicals to groundwater.
- Improper disposal or storage of wastes.
- Chemical spills at local industrial sites.

Many groundwater sources are safe for drinking while some are unsafe. About 50% of all the under groundwater used in urban areas of developing countries is derived from wells, springs and boreholes and more than 1000million inhabitants in Asia and 150 inhabitants of America rely on such resources [1].

The dependence on groundwater is increasing arid and semi arid regions of the world as a result of vagaries of monsoon and scarcity of surface water [2]; [3]; [4]; [5]. According to the world Health Organization, every year more than 2.2 million people from developing countries die from diseases associated with the lack of access to safe drinking water and inadequate sanitation, WHO [6]. About 60% of all infant mortality worldwide is linked to infections and parasitic diseases, most of them are water related [7]. Most urban population in the world rely on dug wells, boreholes, hand pumps and tube wells for all their groundwater requirements. Its quality is getting deteriorated due to untreated discharge of industrial and urban affluent.

The quantity of water is of vital importance whether for individual or domestic purposes. For water to be of consumable quantity, it must attain a certain degree of purity veritable employing existing water quality standards. Often, the raw water used for domestic purposes is vulnerable to contamination due to natural and human influences, resulting in pollution.

According to [8], drinking water standards are based on two main criteria, namely; the presence of objectionable taste, odour and colour; and the presence of substances with adverse physiological effects. However, mineral enrichment from underlying rocks can change the chemistry of water, making it unsuitable for consumption [9].

Moreover, water can be a source of serious environmental and health problems. The design and development of such water supply system is not coupled and tied with appropriate sanitation measures. According to [10], drinking water can act as passive means of transporting nutrients into the body system. However, the objective or primary concern is providing potable water free from harmful micro-organisms and undesirable and harmful chemicals. Therefore, both the physiochemical and bacteriological assessment of potable water is of paramount importance. Monitoring must be given the highest priority. Groundwater pollution is mainly due to the processes of industrialization and urbanization that have progressively developed over time without any regard for environmental consequences [11].

Southwestern Nigerian is underlain primarily by basement complex rocks of pre-Cambrian age, comprising gneisses, migmatities and schist. When fresh, such rocks have practically no porosity or permeability due to the introducing crystal structure. The groundwater potential in crystalline rock terrains depends therefore on post- emplacement processes such as tectonism, and weathering which could lead to secondary porosity and permeability.

2. Groundwater Contaminants

Contaminants in groundwater are summarized under Inorganic, Organic, Microbiological, and Physical contaminants.

2.1 Inorganic Contaminants

This is displayed in Table 1.

Table 1. Inorganic contaminants found in groundwater.

Contaminant	Source to groundwater	Potential health & other effects
Aluminum	Occurs naturally in some rocks and drainage from mines	Can precipitate out of water after treatment, causing increased turbidity or discoloured water.
Antimony	Enters environment from natural weathering, industrial production, municipal waste disposal, and manufacturing of flame retardants, ceramics, glass, batteries, fireworks and explosives.	Decreases longevity, alters blood levels of glucose and cholesterol in laboratory animals exposed at high levels over their lifetime.
Arsenic	Enters environment from natural processes, industrial activities, pesticides, and industrial waste, smelting of copper, lead and zinc ore.	Causes acute and chronic toxicity, liver and kidney damage, decreases blood hemoglobin. A carcinogen.
Barium	Occurs naturally in some limestones, sandstones, and soils in the eastern United States.	Can cause a variety of cardiac, gastro-intestinal, and neuromuscular effects. Associated with hypertension and cardiotoxicity in the animals.
Beryllium	Occurs naturally in soils, groundwater, and surface water. Often used in electrical industry equipment and components, nuclear power and space industry. Enters the environment from mining operations, processing plants, and improper waste disposal. Found in low concentrations in rocks, coal, and petroleum and enters the ground.	Causes acute and chronic toxicity, can cause damage to lungs and bones. Possible carcinogen.
Cadmium	Found in low concentrations in rocks, coal and petroleum and enters the	Replaces zinc biochemically in the body and causes high blood pressure, liver and kidney damage, and

	groundwater and surface water when dissolved by acidic waters. May enter the environment from industrial discharge, mining waste, metal plating, water pipes, batteries, paints and pigments, plastic stabilizers, and landfill leachate.	anemia. Destroys testicular tissue and red blood cells. Toxic to aquatic biota.
Chloride	May be associated with the presence of sodium in drinking water when present in high concentrations. Often from saltwater intrusion, mineral dissolution, industrial and domestic waste.	Deteriorates plumbing, water heaters, and municipal water-works equipment at high levels. Above maximum contaminant level, taste becomes noticeable.
Chromium	Enters environment from old mining operations, runoff and leaching into groundwater, fossil fuel combustion, cement-plant emissions, mineral leaching, and waste incineration. Used in metal plating and as a cooking-tower water additive.	Chromium III is a nutritionally essential element. Chromium IV is much more toxic than Chromium III and causes liver and kidney damage, internal hemorrhaging, respiratory damage, dermatitis, and ulcers on the skin at high concentrations.
Copper	Enters environment from metal plating, industrial and domestic waste, mining, and mineral leaching.	Can cause stomach and intestinal distress, liver and kidney damage, anemia in high doses. Imparts an adverse taste and significant staining to clothes and fixtures. Essential trace element but toxic to plants and algae at moderate levels.
Cyanide	Often used in electroplating, steel processing, plastics, synthetic fabrics, and fertilizer production; also from improper waste disposal.	Poisoning is the result of damage to spleen, brain, and liver.
Dissolved solids	Occur naturally but also enters	May have an influence on the acceptability of

	environment from man-made sources such as landfill leachate, feedlots, or sewage. A measure of the dissolved "salts" or minerals in the water. May also include some dissolved organic compounds.	water in general. May be indicative of the presence of excess concentrations of specific substances not included in the Safe Water Drinking Act, which would make water objectionable. High concentrations of dissolved solids shorten the life of hot water heaters.
Fluoride	Occurs naturally as an additive to municipal water supplies; widely used in industry.	Dcreases incidence of tooth decay but high levels can stain or mottle teeth. Causes crippling bone disorder (calcification of the bones and joints) at very high levels.
Hardness	Result of metallic ions dissolved in the water; reported as concentratio n of calcium carbonate. Calcium carbonate is derived from dissolved limestone or discharges from operating or abandoned mines.	Decreases the lather formation of soap and increases scale formation in hot-water heaters and low pressure boilers at high levels.
Iron	Occurs naturally as a mineral from sediment and rocks or from mining, industrial wastes and corroding metal.	Imparts a bitter astringent taste to water and a brownish colour to laundered clothing and plumbing fixtures.
Lead	Enters environment from industry, mining, plumbing, gasoline, coal, and as a water additive.	Affects red blood cells chemistry, delays normal physical and mental development in babies and young children. Causes slight defects in attention span, hearing and learning in children. Can cause slight increase in blood pressure in some adults. Probable carcinogen.
Manganes e	Occurs naturally as a mineral from sediment and rocks or from mining and industrial waste.	Causes aesthetic and economic damage, and imparts brownish stains to laundry. Affects taste of water, and causes dark brown or black stains on plumbing fixtures. Relatively non-toxic to animals but toxic to plants at high levels.
Mercury	Occurs as an inorganic salt and as	Causes acute and chronic toxicity. Targets the

	organic mercury compounds. Enters the environment from industrial waste, mining, pesticides, coal, electrical equipment (batteries, lamps switches), smelting, and fossil fuel combustion.	kidneys and can cause nervous system disorders.
Nickel	Occurs naturally in soils, groundwater, and surface water. Often used in electroplating, stainless steel and alloy products, mining, and refining.	Damages the heart and liver of laboratory animals exposed to large amounts over their lifetime.
Nitrate (as Nitrogen)	Occurs naturally in mineral deposits, soils, seawater, freshwater systems, the atmosphere, and biota. More stable form of combined nitrogen in oxygenated water. Found in the highest levels in groundwater under extensively developed areas. Enters the environment from fertilizer, feedlots, and sewage.	Toxicity results from the body's natural breakdown of nitrate to nitrite. Causes "bluebaby disease", or methemoglobinemia, which threatens oxygen-carrying capacity of the blood.
Selenium	Enters environment from naturally occurring geologic sources , sulphur, and coal.	Causes acute and chronic toxic effects in animals—"blind staggers" in cattle. Nutritionally essential element at low doses, but toxic at high doses.
Silver	Enters environment from ore mining and processing, product fabrication, and disposal. Often used in photography, electric and electronic equipment, sterling and electroplating, alloy and solder. Because of great economic value of	Can cause cargyria, a blue-gray colouration of the skin, mucous membranes, eyes, and organs in humans and animals with chronic exposure.

	silver, recovery practices are typically used to minimize loss.	
Sodium	Derived geologically from leachate of surface and underground deposits of salt and decompositio n of various minerals. Human activities contribute through de-icing and washing products.	Can be a health risk factor for those individuals on a low-sodium diet.
Sulphate	Elevated concentratio ns may result from saltwater intrusion, mineral dissolution, and domestic or industrial waste.	Forms hard scales on boilers and heat exchangers; can change the taste of water, and has a laxative effect in high doses.
Thallium	Enters the environment from soils; used in electronics pharmaceutic als manufacturin g, glass, and alloys.	Damages kidneys, liver, brain, and intestines in laboratory animals when given in high doses over their lifetime.
Zinc	Found naturally in	Aids in the healing of
	water, most frequently in areas where it is minned. Enters the environment from industrial waste, metal plating, and plumbing, and is a major component of sludge.	wounds. Causes no ill health effects except in very high doses. Imparts an undesirable taste to water. Toxic to plants at high levels.

2.2 Organic Contaminants

These contaminants are shown in Table 2.

Table 2. Organic Contaminants found in ground water

Contaminants	Sources to groundwater	Potential health and other effects
Volatile organic compounds	Enters the environment when used to make plastics, dyes, rubbers, polishes, solvents, crude oil, insecticides, inks, varnishes, paints, disinfectants, gasoline products, pharmaceutica ls, preservatives, spot removers, paint removers, degreasers,	Can cause cancer and liver damage, anemia, gastrointestin al disorders, skin irritation, blurred vision, exhaustion, weight loss, damage to the nervous system, and respiratory tract irritation.

	and many more.	
Pesticides	Enters environment as herbisides., insecticides, fungicides, rodenticides, and algicides.	Cause poisoning, headaches, dizziness, gastinointestinal disturbance, numbness, weakness, and cancer. Destroys nervous system, thyroid, reproductive system, liver and kidney.
Plasticizers, Chlorinated solvents, benzo [a] pyrene, and dioxin.	Used as sealant, linings, solvents, pesticides, plasticides, components of gasoline, disinfectant, and wood preservative. Enters the environment from improper waste disposal, leaching runoff, leaking storage tank, and industrial runoff.	Causes cancer. Damages nervous and reproductive systems, kidney, stomach, and liver.

2.3 **Microbiological contaminants**

These contaminants are displayed in Table 3.

Table 3: Microbiological Contaminants found in Groundwater

Contaminants	**Sources of groundwater**	**Potential health and other effects**
Coliform bacteria	Occur naturally in the environment from soils and plants and in the intestines of humans and other warm-blooded animals. Used as an indicator for the presence of pathogenic bacteria, viruses, and parasites from domestic sewage, animal waste, or plant or soil material.	Bacteria, viruses, and parasites can cause polio, cholera, typhoid fever, dysentery, and infectious hepatitis.

2.4 Physical Conterminants

They are in Table 4.

Table 4. Physical characteristics of ground water

Contaminant	Sources to groundwater	Potential health and other effects
Turbidity	Caused by the presence of suspended matter such as clay, silt, and fine particles of organic matter, plankton, and other microscopic organisms. A measure of how much light can filter through the water sample.	Objectionable for aesthetic reasons. Indicative of clay or other inert suspended particles in drinking water. May not adversely affect health but may cause need for additional treatment. Following rainfall, variations in groundwater turbidity may be an indicator of surface contamination.
Colour	Can be caused by decaying leaves, plants, organic matter, copper, iron, and manganese, which may be objectionable. Indicative of large amounts of organic chemicals, inadequate treatment, and high disinfection demand. Potential for production of excess amounts of disinfection byproducts.	Suggests that treatment is needed. No health concerns. Aesthetically unpleasing.
pH	Indicates, by numerical expression, the degree to which water is alkaline or acidic. Represented on a scale of 0-14, where 0 is the most acidic, 14 is the most alkaline, and 7 is neutral.	High pH causes a bitter taste, water pipes and water-using appliances become encrusted; depresses the effectiveness of the disinfection of chlorine, thereby causing the need for additional chlorine when pH is high. Low pH water will corrode or dissolve metals and other substances.
Odour	Certain odours may be indicative of organic or non-organic contaminants that originate from municipal or industrial waste discharges or	

	from natural sources.	
Taste	Some substances such as certain organic salts produce a taste without an odour and can be evaluated by a taste test. Many other sensations ascribed to the sense of taste actually are odours, even though the sensation is not noticed until the material is taken into the mouth.	

Source: [12]

3. Discussion

Raw water contains natural impurities or/and impurities arising from human activities. Most of the time, these impurities are above tolerable levels as specified by various water quality standards. Hence, it is required that water from different sources be examined and treated if necessary. Harmful contaminants present in water may cause liver and kidney diseases, cancer, typhoid, diarrhea, and other water related diseases.

Conclusion

It is recommended that there should be monitoring of locations of landfills and septic tanks sites. According to [13], solid waste dump sites should be discouraged, since this is not a solid waste disposal method, being source of leachate that enters groundwater. Location of these facilities should not be very close to wells to minimize incidence of leachate entering our groundwater and polluting it. It is also recommended that there should be periodic examination of water to ensure its potability before usage.

The health departments of local government authorities need to improve on their effectiveness in the monitoring of control efforts.

Moreover, government policies on waste disposal and management should be enacted and strictly enforced. These policies should encompass replacement of dumpsites by sanitary/ and fills to ensure proper waste disposal practice that is environmentally safe and with public health protection. Adoption of sanitary landfill ensures that leachates are protected from entering the groundwater by usage of clay or plastic hiring at the bottom of landfills to prevent percolators of leachate into groundwater reserve.

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