AN OVERVIEW OF SOURCES AND EXTENT OF GROUNDWATER CONTAMINATION IN NIGERIA: THE NEED FOR WATER QUALITY SURVEILLANCE

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Abstract

Groundwater is an important source of portable water for more than half of the nation’s population and nearly all its rural population. In recent years, widespread reports of bacteria, nitrate, synthetic organic chemicals, heavy metals and other pollutants in ground water have increased public concern about the quality of groundwater (Anyakora and Momodu, 2009). This paper is aimed at exposing what the public knows and don’t know about ground water quality, examine the causes of groundwater contamination and state the extent to which the nation’s groundwater supplies are at risk to human life. A case study was also reviewed. Recommendations were also given.

Key words: Groundwater, contamination, heavy metals, Maximum Contaminant Level (MCL), Geochemical, anthropogenic and Leachate.

Water is one of the most abundantly available substance in nature after air and considered as one of the essentials that support all forms of plant and animal life. (Vanloon and Duffy, 2005) Generally, water is obtained from two basic natural sources: surface water such as fresh water lake, river etc and groundwater; obtained from wells and boreholes. (McMury and Fay, 2004, Mendie, 2005).

Groundwater is usually referred to as subsurface water that fills open spaces in sediments and rocks or occupy cracks, voids between mineral grains and other cavities. Groundwater becomes contaminated when toxic substances such as bacteria, nitrate, synthetic organic chemicals, heavy metals etc. dissolved in surface water are carried down or leached to the aquifer with the percolating water (Mc Murry and Fay 2004).

Groundwater according to studies by Moody, (1996), in a U.S geological survey; provides an estimated:

* 22 percent of all fresh water withdrawals
* 53 percent of drinking water for the total population and 97 percent of drinking water for the rural population
* 40 percent public water supply withdrawals
* 46 percent of domestic and commercial use
* 24 percent of industrial and mining use
* 34 percent of agricultural use (mostly irrigation).

This survey shows how high the degree of dependency on ground water in U.S is. In Nigeria, according to Anyakora and Momodu (2009), the use of groundwater has become an agent of development because government is unable to meet the ever increasing water demand. The inhabitants of both urban and rural areas have resorted to alternative ground water sources such as shallow wells and boreholes without adequate knowledge of its health risk to life. Thus this review is in order to create more awareness of the extent of contamination of the only common source of water in Nigeria which is groundwater.

Lagos State Experience of Groundwater Contamination

The recent upsurge in kidney failure, hypertension, cancers, mental decline, memory loss, hearing loss, skin diseases in and around Lagos state have necessitated the comprehensive study by
Anyakora and Momodu (2009) on ground water contamination by heavy metals and the probable link thus established.

The work revealed that previous studies have shown that the most common heavy metals that humans are exposed to are Aluminium (Al), Arsenic (Ar), Cadmium (Cd), Lead (Pb) and Mercury (Hg). Aluminium has been associated with Alzheimer’s and Parkinson’s disease, senility and pre-senile dementia, Alzheimer’s disease is a brain disorder that destroys brain cells, causing memory loss and problems with thinking and behaviours, severe enough to affect work, lifelong hobbies or social life.

Arsenic exposure has been shown to cause among other illness or symptoms of cancer, abdominal pain and skin lesions. Cadmium exposure produces kidney damage and hypertension. Lead has been found to be a cumulative poison and a possible human carcinogen while mercury toxicity results in mental disturbance and impairment of speech, hearing, vision and movement. In addition, Lead and Mercury may cause the development of auto-immunity in which a person’s immune system attacks its own cells. This can lead to joint diseases and ailment of the kidneys, circulatory system and neurons. At high concentrations, lead and Mercury can cause irreversible brain damage (Anyakora and Momodu, 2005; Ilabor and Oghenejode, 2014).

Studies by Ilabor (2007); Moody (1996); Anyakora and Momodu, (2009) have shown that the quality of these groundwater sources are affected by the characteristics of the media through which the water passes on its way to the groundwater zone of saturation, thus, the heavy metals discharged by industries, traffics, municipal wastes, hazardous waste sites as well as from fertilizers for agricultural purposes and accidental spillages from tankers can result in a steady rise in contamination of groundwater.

Anyakora and Momodu’s study, 2009, assessed heavy metal contamination of groundwater in middle class neighbourhood of Lagos. About 49 wells and borehole water samples were analysed using Atomic Absorption spectrophotometer (AAS) for their Aluminium, Cadmium and lead content and their levels compared with the World Health Organisation (WHO) specified Maximum Contaminant Level (MCL). According to the WHO, the Maximum Contaminant Level (MCL), for Aluminium, Cadmium and Lead are 0.2mgL\(^{-1}\), 0.003mgL\(^{-1}\) and 0.01mgL\(^{-1}\) respectively. According to Anyakora and Momodu 2009, none of the samples analysed contained Aluminium in concentrations above the MCL. However, the metal (AL) was found to be present in 93.88 percent of the samples analysed. Over 38 percent of the samples had Cadmium present in them and 32.65 percent of the samples had Cadmium concentrations above the MCL. Almost 60 percent of the samples had detectable level of Lead while 36.73 percent of the sample had lead concentration above the MCL.

In general, 97.96 percent of all samples analysed contained one or more of the three heavy metals studied each in varying concentrations. The conclusion was that the results show high concentration of these heavy metals and in some cases the levels were above WHO specified maximum contaminant level. This suggests a significant health risk to this population given the toxicity of these metals and the fact that for many, hand dug wells and boreholes are the only sources of water supply in the environment (Anyakora and Momodu, 2009).

Susceptibility and Causes of Groundwater Contamination

One fourth (1/4) of the average 4.2 trillion gallons of precipitation that falls each day on the conterminous United States infiltrates the soil and recharges local aquifers, the sediments and rocks that store and transport groundwater. In general, shallow, permeable water table aquifers are the most susceptible to contamination, but susceptibility of all aquifers to contamination is determined largely by such site-specific characteristics such as:

* distance from the contamination source to the aquifer and residence time of the water in the unsaturated zone;
* presence of clay and organic matter in the insaturated zone materials;
* potential of a particular contamination to brodegrade and decompose;
* amount of precipitation, which in recharge areas may decrease the amount of water that moves downward to the aquifer (Moody, 1996).

Ground water contamination can be caused by geochemical means (natural) or anthropogenically induced (man-made). Groundwater commonly contains one or more naturally
occurring chemicals, leached from soil or rocks by percolating water in concentrations that exceed WHO or Nigerian drinking water standards or otherwise impair its use (Oyekul and Eludoyin, 2010).

1. **Natural Sources:**
   * **Dissolved Solids and Chloride:** One of the most common water quality concerns is the presence of dissolved solid measured as Total Dissolved Solids (TDS) and chloride; measured as salinity both titrimetrically in concentrations above the recommended maximum limits for WHO drinking water standards. (500mgL\(^{-1}\) for dissolved solids and 250mgL\(^{-1}\) for chloride). Such concentrations are found at the seaward end of all coastal aquifers and are quite common in aquifers at depths greater than a few hundred feet below the land surface in many parts of the United States as well as Nigeria (Vanloon and Duffy 2005).

   * **Iron and Manganese:** Although Iron and Manganese are not particularly toxic, concentrations in water greater than the limits for WHO standards (0.3mgL\(^{-1}\) for Iron and 0.05mgL\(^{-1}\) for manganese) can impair the taste and colour of water: staining plumbing fixtures, glassware and laundry; forming encrustations on well screens thereby reducing well-pumping efficiency. (Adepoju et al, 2009).

   * **Nitrate-Nitrogen:** Most groundwater not affected by human activity contains less than 10mgL\(^{-1}\) nitrate-nitrogen, the maximum concentration allowed by WHO drinking water standards. Nationwide, nitrate-nitrogen concentrations of less than 0.2mgL\(^{-1}\) generally represent natural conditions, whereas values greater than 3 mgL\(^{-1}\) may indicate the effects of human activities. Although relatively nontoxic, nitrate may be reduced by bacteria to nitrite in the intestines of newborn infants and cause the disease “methemoglobinemia”. Nitrate can also react with amines in the human body to form N-nitrosamines:- carcinogenic chemicals known to induce tumors in laboratory animals and thought to be linked to human cancers. (Mendie, 2005).

2. **Human Activities:** Contaminants can enter groundwater from more than 30 different generic sources related to human activities. These sources are commonly referred to as either point or non-point sources. Point sources are localized in areas of an acre or less, while non point sources are dispersed over broad areas.

   The most common sources of human induced (anthropogenic) groundwater contamination can be grouped into four categories: (Moody, 1996), (a)waste disposal practices (b) storage and handling of materials and wastes (c) agricultural activities (d) saline water intrusion.

(a) **Waste Disposal Practices:** Perhaps the best known sources of groundwater contamination are associated with the storage or disposal of liquid and solid wastes. The organic substances most frequently reported in groundwater as resulting from waste disposal in decreasing order of occurrence are: trichloroethylene > chloroform> benzene> pentachlorophenol> tetrachloroethylene > creosote > phenolic compounds > 1,1,1 trichloroethane > toluene > xylene.

**Waste Disposal can take a number of Forms namely:**

- **Septic systems:** Largest source of volume of waste discharged to the land, are sources of bacteria, viruses, nitrate, phosphorus, chloride and organic substances including organic solvents such as trichloroethylene that are sold commercially to “clean” the systems.

- **Municipal and Industrial landfills:** Some hazardous waste materials may be deposited in municipal landfills and underlying groundwater may become contaminated. Wastes deposited at industrial landfills include a large assortment of trace metals acids, volatile organic compounds and pesticides, which may cause significant local contamination.

- **Surface Impoundments:** They are used to store, treat or dispose of oil and gas brines, acidic mine wastes, industrial wastes (mainly liquids), animal wastes, municipal treatment plant sludge’s and
cooling water. Some of these impoundments have significant potential for contaminating groundwater.

- **Waste Injection Wells**: It disposes of liquid wastes underground. Of particular concern is the widespread use of drainage wells to dispose of urban storm water runoff and irrigation drainage. Contaminants associated with drainage wells include: suspended sediments, dissolved solids, bacteria, sodium, chloride, nitrate, phosphate, lead and organic compounds, including pesticides.

- **Direct application of stabilized wastes on the land**: In many places, solid and liquid wastes are placed or sprayed on the land, commonly after treatment and stabilization. Contamination can occur from improper land-disposal techniques.

(b) **Storage and Handling of Materials and Wastes**: Groundwater contamination as a result of storage and handling of materials include leakages from both above-ground and underground storage tanks as well as unintentional spills or poor housekeeping practices in the handling and transferring of materials on industrial and commercial sites. Under this there are:

  * Leaking underground storage tanks: Underground storage tanks appear to be a leading source of benzene, toluene and xylene contaminants, all of which are organic compounds in diesel and gasoline fuels.
  * Transporting and stockpiling: Many materials and wastes are transported and then temporarily stored in stockpiles before being used or shipped elsewhere. Precipitation can leach potential contaminants from such stockpile; storage containers can corrode and leak and accidental spills can occur as many as 10,000 to 16,000 per year according to USEPA estimates.
  * Mining practices of coal, uranium, lead etc. and other related mine spoil can lead to groundwater contamination through shafts and tunnels, exposure of coal to oxygen to form tetraoxosuphate (vi) acid, contaminants from tailings which can leach into groundwater.
  * Oil-well brines, usually separated from oil and stored in surface impoundments. EPA estimates that 125,100 brine disposal impoundments exist that might affect local groundwater supply.

3. **Agricultural Activities**: Agriculture is one of the most widespread human activities that affects the quality of groundwater through:

- **Fertilizers**: if nitrogen supply exceeds nitrogen uptake by crops, excess nitrogen can be leached to groundwater. In such areas, local nitrate-nitrogen concentrations may exceed the WHO water standard of 10mgL⁻¹.

- **Pesticides**: pesticides most frequently detected in groundwater are the fumigants (ethylienedibromide, 1,2-diechloropropane); the insecticides (aldicarb, carbofuran and chlordane) and herbicides (alachlor and atrazine).

- **Feedlots**: Feedlots confine livestock and poultry and create problems of animal-waste disposal. Feedlots wastes often are collected in impoundments from which they might infiltrate into groundwater and increase nitrate concentration.

- **Irrigation**: percolation of irrigation water into soils dissolve soil salts and transport them downward. Evapotranspiration of applied water from the rootzone concentrates salts in the soil and increases the salt load to the groundwater.

- **Chemigation**, the practice of mixing and distributing pesticides and fertilizers with irrigation water, may cause contamination if chemicals are applied than crops can use. (Moody, 1996).

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*Knowledge Review Volume 33 No. 2, December, 2015: ISSN 1595-2126*
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Conclusions

From the results of Anyakora and Momodu 2009, information available on the causes of groundwater contamination, the tendency of the quality of groundwater sources in most urban cities in Nigeria to be contaminated is high. This calls for the agencies in charge of a urban and rural water supply such as River Basins, Ministries of Water Resources (Federal and State) to enforce a system for continuous monitoring (surveillance) of these groundwater contaminants every six (6) months. If contaminants level are found to be consistently above the MCL, the water supplier (private or public) must take steps to reduce the amount of the contaminants so that it is consistently below the level. The following treatment methods have been approved by USEPA for removing heavy metals as contaminants in the first instance: Coagulation/Filtration, Ion Exchange, Lime Softening, Reverse Osmosis.

If also for instance the levels of heavy metals and other contaminants exceed the MCL, the system (Agencies) must notify the public via newspapers, radio, television and other media. Additional actions, such as providing alternative drinking water sources (supplies) may be required to prevent serious risks to public health.

References


